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ORIGINAL ARTICLES.

I.—Evidences of a Mandible of a new Labyrinthodont from the Upper Karroo Beds of Cape Colony (*Ptychosphenodon Browni*).

By H. G. Seeley, F.R.S., F.G.S., King's College, London.

(PLATE XIX.)

I AM indebted to Mr. Alfred Brown, of Aliwal North, for the opportunity of describing a small fragment of a lower jaw of a Labyrinthodont which shows some unusual characters in the dentition and in the composition of the mandible (Pl. XIX. Fig. 1). Hitherto the evidence of the structure of the mandible has been imperfectly recorded in these South African reptiles.

Mr. Brown's specimen is a small transverse segment, probably from the left ramus, at some little distance behind the symphysis. This position may be indicated by an angular ridge upon the inner side, which is becoming more elevated as it extends forward. There is no suggestion of the original length of the mandible, which may have been eighteen inches. The fragment is little more than an inch and a half long. In section the jaw is subquadrate, somewhat depressed, being two inches wide and an inch and a half deep. The external surface of the bones shows no trace of sculpture. From its slightly water-worn condition the specimen (Fig. 1) was probably obtained from the reconstructed bed at the railway station at Aliwal North, which yields Theriodonts and other fossils.

The external bone is apparently vertical, traversed on the lower third by a deep longitudinal groove, in which there is a faintly marked suture. The dentary bone above the groove is slightly convex up to the alveolar margin, and shows what may be a sinuous impression above the groove. The bone below the groove, which may be infra-dentary, is well rounded on to the base.

The base is flattened, but slightly convex from side to side, and is marked by a median groove which traverses a median inferior bone defined laterally by two irregular sutures. The base of the jaw is limited towards the inner side by a slight angular ridge. The inner side is divided into upper and lower flattened areas by the median angle already referred to. There is a longitudinal suture in the middle of the upper portion of the palatal surface.

The transverse sections, back and front, are vertical and clean, practically unworn, and of similar transversely oblong form.

In the middle is an oblong central cavity (M.), which is less than an inch wide and less than half an inch deep. From it the sutures radiate which separate the constituent bones. When the specimen is examined from the external surface the only well-marked sutures are upon the base, so that on such evidence the jaw might be interpreted as formed of two bones. The narrow straight lateral line between the surangular and splenial on the inner side might pass for a crack in the specimen. Similarly, the line in the external groove between the elements of the dentary and infra-dentary might have been supposed to be the opposite side of the same fracture but for the transverse sections. These lateral conditions are found to be natural divisions when the broken ends of the fragment are examined. More or less serrated and angulated sutures are marked by lines of black matrix as represented in the figure (see Pl. XIX, Fig. 1). They are not all followed with equal facility, and the external dentary bone is obscurely divided into superior and inferior elements by suture, for the division is less evident at the other fractured end. The complicated suture between the internal splint bone, which I regard as the splenial, and the two bones on which it rests is also less distinct on the posterior fracture in this specimen, where the surface is more weathered, but may be followed with a magnifying-glass. The most interesting suture is the vertical division, showing that two distinct parallel bones support the teeth in two parallel rows, of which the outer row is rather the longer.

The external dentary bone carries five teeth, which are close set. Their crowns are broken and show no trace of a pulp cavity. The basal attachment is four times as wide as long from front to back. The attachment of the teeth is of a pleurodont type, for the external alveolar border rises fully half an inch above the rounded internal exposures of the crowns; and on their inner side the dentary bone rises as an oblique rounded strip from the groove in which these teeth are imbedded. Both front and back fractures pass through the bases of crowns of teeth. In the middle of the base of the tooth, on what may be the posterior fracture, the crown descends in a small short oblong portion into a shallow socket, and shows the same folded structure as the rest of the tooth. The smooth surfaces of the teeth are marked with fine parallel vertical grooves upon the enamel, which vary in depth on the several teeth. Each crown decreases in size as it ascends, by becoming narrower from within outward.

The bone which abuts against the dentary above the Meckelian vacuity on the inner side of the jaw is regarded as the surangular bone, and beneath it is the angular bone. The lateral junction between these bones is hidden by the splint-like covering of the splenial. The determination of these elements rests upon the sutures shown in the transverse sections. But if there is an infra-dentary, there may also be an infra-angular; and these elements may be upper and lower divisions of the angular bone.

The upper or surangular bone is small compared with the dentary, to which it is parallel and internal. At its suture with the dentary

bone it rises above the level of the dentary on the superior dentigerous surface, where it is roughened and vascular, forming a supporting outer ledge for the teeth which it carries, which is of the same kind as the external elevated alveolar border of the dentary bone. The teeth, however, are smaller; they are not so close set in this specimen; each has a transversely ovate base, and is implanted in a shallow conical pit or socket, which the base of the tooth does not completely fill, for a groove extends round the base of the inner side of the tooth. The base is invested with an osseous cement, above which the crown shows vertical grooves of the same type as are seen upon the row of teeth in the dentary bone. At one end of the specimen a fracture passes through the base of a tooth, and shows the same folded structure in these teeth as in the parallel dentary tooth; next is a large empty socket, the base of which is not clean from matrix; this is followed by a broken tooth in position; and lastly, after an interval, the terminal fracture passes through the middle of a clean empty conical socket. The teeth of this inner row appear to diminish in size as they extend backward.

As the teeth are broken to the level of the alveolar margin of the dentary I availed myself of the opportunity to obtain a transverse section of a portion of a tooth on the dentary bone at the level of the alveolar border where the tooth is ovate. In microscopic enlargement the labyrinthic structure is much less folded and simpler than in any other tooth from these rocks which I have examined (Pl. XIX, Fig. 2).

In the Museum of the University of Munich a second specimen of the mandible of the same species is preserved, collected at Middelburg in Cape Colony. The late Professor K. v. Zittel placed it in my hands to complete this description. The Munich fossil is a fragment from the right ramus of the mandible, two and three-quarter inches long. It exactly corresponds in its position in the jaw with the fragment of the left ramus from Aliwal North. The anterior fracture is oblique, the posterior fracture is vertical. The sutures are not shown upon the black bone of these ends. The fossil indicates a long narrow skull, with a short mandibular symphysis (Pl. XIX, Figs. 3, 4).

The Middelburg specimen is from a soft matrix, which has been sufficiently removed to show the forms of the teeth and their implantation. The dentary series of teeth gives evidence of nine teeth in a length of two and seven-tenths inches, so that each tooth occupies three-tenths of an inch, as in the other specimen, and the basal attachment is eight to nine-tenths of an inch wide. Five teeth are lost, and as these are consecutive the bases are seen to be divided from each other transversely by ridges, forming shallow sockets (Fig. 4), rather more pronounced than those sometimes seen in the not dissimilar but deeper groove which carries the teeth in *Ichthyosaurus*.

The crowns are better preserved, and have a singularly compressed, sharp, triangular, wedge-shaped aspect, as though used for catching fish. They are flattened laterally, rounded on the narrow outer and inner aspects, which are straight and converge upward to a sharp point. Each of these wedge-shaped teeth was about one inch and a quarter long, but only one shows the extremity of the crown. Seen from the end, the contour of a tooth is not unlike a large longitudinally

grooved vomerine tooth of *Labyrinthodon*; it curves slightly inward (Pl. XIX, Fig. 2). On the inner side of the teeth the dentary bone rises in the same smooth rounded surface as in the other fossil, but externally an osseous cement appears to extend on to the tooth from the alveolar border.

The second inner row of teeth originates just behind the anterior fracture, and includes indications of about twelve close-set teeth, carried in a groove which gradually widens as it extends backward. The teeth are smaller than the dentary series, but the crowns resemble them in all ways, being similarly compressed from front to back and wedge-shaped. The early crowns are broken, and several are missing from their sockets. These teeth are implanted in the bone which extends down the jaw between the dentary bone and the splenial, which is probably the surangular bone. Below the suture the splenial bone is rounded and shows no trace of the angular condition of the other specimen. The base of the jaw is less flattened, traversed by three rather stronger little ridges; but the two sutures which are so marked a feature of the specimen from Aliwal North are not visible. The external lateral groove on the dentary bone becomes a circular tubular canal as it extends backward, running below the teeth. This groove is characteristic of Ichthyosaurs. A fine suture appears to run down its length, as in the fragment from Aliwal North separating the lower half of the bone as infra-dentary. The presence of such an ossification is an interesting approximation to the condition in Holoptychian fishes, in which Dr. Traquair's specimens show two parallel rows of teeth; and those fishes have their tooth substance folded in a way that approximates to Labyrinthodonts, and especially to this fossil.

The presence of these five bones in the mandible, which does not include the articular bone or the coronoid in the specimens preserved, appears to show that some South African Labyrinthodonts include seven bones in each ramus of the mandible. This character may not vary the general reptilian affinities of the skull, but appears to be a departure from the reptilian type in the mandible, which may approximate towards a lower type. The additional bone in the mandible is quite distinct from that described by Dr. Branson.

EXPLANATION OF PLATE XIX.

FIG. 1.—Transverse anterior fracture of ramus of mandible in Aliwal North specimen, showing bones about the Meckel cartilage cavity (M): dentary and infra-dentary externally, surangular and angular internally, overlapped by the splenial bone on the inner side. *a*, anterior end.

,, 2.—Transverse section, much enlarged, of part of a dentary tooth of the same specimen. The section was prepared by Professor Chapman, of Melbourne, and photographed by A. Campion, Esq., in the metallurgical laboratory, Coopers Hill.

,, 3.—End view of the Middelburg specimen in the Munich University Museum, showing an entire external tooth, with natural curvature of the crown.

,, 4.—The same specimen seen from above, showing a succession of empty tooth sockets on the mandible.

Figs. 1, 3, and 4 are of the natural size.

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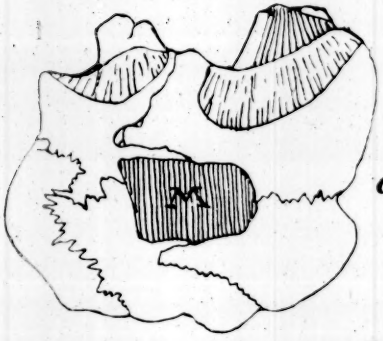

a

Labyrinthodont Reptilian remains from the Upper Karroo Beds of Cape Colony.

II.—Nathorst's use of Collodion Imprints in the Study of Fossil Plants.

By F. A. Bather, M.A., D.Sc., F.G.S., British Museum (Natural History).

THE following note is based on two papers by Professor A. G. Nathorst[1] and on further details which he has kindly communicated by letter. For the loan of the block (Fig. 1) thanks are due to Dr. H. Munthe, Secretary of Geologiska Föreningen i Stockholm.

By the term 'collodion imprint' is meant the impression of any surface on a thin film of collodion. Such an impression is obtained by letting a drop or two of collodion dissolved in ether fall on the surface to be copied. The ether evaporates rapidly, so that in two or three minutes the film is hard. If it does not of its own accord come loose at the corners, it is easily raised by a needle or sharp knife. It is then lifted on to a glass microscope-slide and preserved dry under a cover-slip held in position by gummed strips of paper or by Canada balsam. When the imprint is very sharp, the film can, if desired, be preserved in glycerine-jelly without its distinctness being greatly affected. Some films may be less successful than others, and some may curl too much, so that it is as well to take more than one imprint. In any case it is advisable to throw away the first made, since it usually retains some dust from the surface of the object, whereas following films will be free from this. If the collodion solution is too thick it may be thinned by the addition of ether or of ether and alcohol. The thicker the solution, the more liable is it to air-bubbles; the thinner solution gives a thinner and clearer film, which may sometimes be an advantage, also it takes longer to dry, which is of no great consequence. No definite prescription can be given as to thickness; one must find out for oneself the kind of solution most suitable for the objects with which one is dealing.

The film placed on the slide is examined under the microscope by transmitted light. Since the film is thicker over the depressions of the original surface, it appears darker over these tracts, so that the structure is easily seen. In fact, quite high powers of the microscope can be used, and photomicrographs taken. Professor Nathorst reproduces one such photograph with a magnification of 500 diameters (Fig. 1). The illumination of the film should not be directly from below, but oblique, the mirror being shifted until the best effect is obtained.

Such collodion films have long been used in the measurement of microscopic objects, especially in the preparation of copies of the eye-piece-micrometer in order to determine the magnifying power of the microscope. They have also been employed by botanists to copy the cuticular surface of living leaves for the study of physiological processes.[2] L. Jost also briefly stated in 1902 that he had successfully

[1] "Kollodiumaftryck såsom hjälpmedel vid undersökning af fossila „växter"': Geol. Fören. Förhandl., Bd. xxix, pp. 221–227, April, 1907. "Über die Anwendung von Kollodiumabdrücken bei der Untersuchung fossiler Pflanzen": Arkiv för Botanik, Bd. vii, No. 4, 8 pp., 1 pl., August, 1907.

[2] L. Buscalioni e G. Pollacci: "L'applicazione delle pellicole di Collodio allo studio di alcuni processi fisiologici nelle piante ed in particolar modo alla Traspirazione," and "Ulteriori ricerche sull' applicazione, etc.": Atti dell' Istituto botanico dell' Università di Pavia, ser. II, vol. vii, Milan, 1902.

applied the method to the study of the surface structure in fossil plants. It is, however, to Professor Nathorst that we are indebted for the first publication of results obtained by it in the study of fossils,[1] and for the first account of its advantages in palæobotany. From the many instances of the successful use of this method given by Professor Nathorst a few will now be noticed.

The first attempt was naturally one to study well-preserved cuticles of carbonised leaves. In the case of *Baiera spectabilis*, however, a ginkgo form from the Coal-measures of Scania, the attempt was quite unsuccessful. In the case of some carbonised leaves of dicotyledons it was occasionally possible to observe a suggestion of the contours of the elongate cells over the veins and their branches; but this was of no particular interest.

Fig. 1.—Microphotograph (× 500 diam.) of a collodion film showing a stoma and the outer sculpture of the cell-membrane on the upper surface of a leaf of *Tussilago farfara* in the calcareous tufa of Benestad in Scania. (Lent by Geologiska Föreningen i Stockholm.)

Better results were obtained with the sporangia of fossil ferns. In his description of *Dictyophyllum exile* last year, Professor Nathorst was able to publish photographs of those organs enlarged 8 diameters; but the use of films enabled him to study the same bodies with the microscope, and he now reproduces a photograph enlarged 45 diameters. Fossil sporangia are best studied by this method when they have a well-developed annulus, but good imprints have also been taken from the sporangia of *Todites Williamsoni* in which this is not the case.

Occasionally some sporangia adhere to the collodion film and are pulled away with it. This was the case with a specimen of *Thaumatopteris Schenki*. By laying the film in Eau de Javelle the walls of the sporangia were dissolved, and the spores, adhering to the film, exposed in their undisturbed position (*op. cit. ult.*, 1907, pl. ii, fig. 18).

[1] "Ueber *Thaumatopteris Schenki* Nath.": K. Sv. Vetenskaps-Akad. Handl., xlii, No. 3, 1907.

Fossil wood is readily studied by this method, especially when silicified. In this case the broken surfaces generally are transverse, radial, and tangential, or at any rate such surfaces can be readily exposed by a few blows of the hammer. Collodion imprints of these are almost equal to thin sections taken in the same directions, and, in coniferous wood for example, show the medullary rays, the tracheids, and the bordered pits with remarkable distinctness. Imprints from a silicified fragment of *Cupressinoxylon*, originally described by Conwentz in 1891, show every cell in the clearest manner even under high powers of the microscope. Wood from Brown Coal, if well preserved, also furnishes good imprints, especially of surfaces in a longitudinal direction.

Plant-remains preserved in the finer sediments of chemical origin, such as calcareous tufa, the Mesozoic silicious rocks of Franz Josef's Land, and some clay ironstones, have also yielded good results. Thus a piece of a Conifer from the tufa of Benestad in Scania gave imprints showing all the points above mentioned. Leaves in tufa have not always been completely embedded before decay set in, and may not always furnish serviceable preparations. A very successful imprint, was, however, made from a leaf in the Scanian tufa, referred by C. Kurck in 1901 to *Tussilago farfara*. This preparation showed the outlines of the epidermis-cells, the hair-scars, the stomata, and the peculiar streakiness of the outer cell-wall, even under a magnification of 500 diameters and upwards (Fig. 1). Thus Kurck's determination was fully confirmed. The imprints taken from these tufaceous fossils must sometimes be cleaned by acid from the adherent calcareous particles.

As regards leaves in the silicious rock from Franz Josef's Land, it is enough to mention that Professor Nathorst now publishes photographs of films showing the structure of the epidermis-cells and the stomata in *Desmiophyllum*, features that Solms Laubach, who studied the same specimens in 1904 with the aid of thin sections, had not been able to discern.

The advantages of the method as applied to fossil plants may now be summed up. It is not claimed that collodion imprints can [illegible] supersede thin sections, although, as the last instance shows, there may be cases in which they reveal even more than the sections [illegible] but there are many cases in which either time or the state of preservation of the specimen, or perhaps its owner, do not permit of thin sections being made; films then form an admirable substitute. It may often be a saving of time to work over a collection rapidly by this means, sorting the fragments into their genera, and selecting for further treatment those that seem to promise best results. Why, it may be asked, not put the specimens directly under the microscope? Because in some cases they are much too large to be so handled, and in any case the structures cannot so easily be seen by reflected light. The last reason reminds one how readily these films can be photographed, although even the excellent photographs reproduced by Professor Nathorst cannot, as he points out, reveal the structure so well as the films themselves when studied with a varying focus. But this suggests another advantage: the films are easily made, and can

be repeated to almost any extent without damaging the specimen, so that it would be a simple matter for any worker to send a set to all his correspondents, or better still to the chief museums.

Professor Nathorst suggests that the method may also prove of service to zoologists, whether neontologists or palæontologists. Certainly it might sometimes enable one to study delicate ornament and to obtain photographs of it with greater ease, especially when the specimen itself is of a dark colour or irregularly spotted with colour. Some of the minuter Bryozoa, or colonial Hydrozoa, or Stromatopores, might perhaps lend themselves to this treatment. I have myself laid in a stock of collodion solution and intend to use the method as occasion offers. Meanwhile it is hoped that the publication of this note will direct the attention of other workers in this country to what promises to be a valuable aid to the palæontologist.

III.—Recession of the Niagara Falls.[1]

By Professor J. W. Spencer, A.M., Ph.D.

FOR many years Niagara Falls and the Great Lakes of America have been special subjects of my researches. These at last have been completed under the Commission from Dr. Robert Bell, acting Director of the Geological Survey of Canada, and later of Mr. A. P. Low, Director, with results beyond anticipation. These were obtained through precise instrumental measurements, borings, and soundings, not hitherto undertaken.

My recent survey of the crest-line (1904–5), compared with that of Professor James Hall, 1842, shows the mean rate of recession to have been 4·2 feet a year, with the average breadth of the gorge produced by the falls being 1200 feet. But a longer record (agreeing with the more recent) has been found by Mr. James Wilson and myself in discovering the position of the Falls in 1678, from the crude description and picture made by Father Hennepin at that time. Between 1890 and 1905 the rate of greater recession diminished.

I succeeded in making soundings under the Falls and throughout the Gorge by the use of Tanner-Blish self-registering tubes, depending upon the hydrostatic pressure, as the current was too strong for the use of an ordinary line. At the Whirlpool, and at some other places, it was necessary to work from a cable swung across the Gorge. Under the Falls themselves, the sounding tubes were inserted in a specially designed buoy which the force of the Fall drove down to the rocks, that had collapsed beneath the Falls themselves. These were reached at 72 feet, while the floor of the river beyond varied from 84 to 100 feet below the surface of the river. Farther down, there was a lateral inner gorge, reaching to 192 feet, which could not have been produced by the present descent of the Falls. An explanation of this, however, was found.

[1] Read before the British Association for the Advancement of Science, Section E (Geography), Leicester, August, 1907. Abstract.

The river at the Whirlpool was measured to a depth of 126 feet, but this was not quite in the middle of the current, where the depth is supposed to be 14 feet greater. Below the Whirlpool the river is shallower. From a short distance below the Falls extending to the Whirlpool, the bottom of the channel has a depth of about 90 feet below the level of Lake Ontario.

At points a short distance within the end of the gorge and also beyond, a narrow, deep, inner channel, reaching to about 180 feet below the level of Lake Ontario, was discovered. This established the fact that the aggregate height of the different parts of Niagara Falls was more than 500 feet.

A terrace formed upon the birth of the Falls shows that they were only 35 feet high. The present height is 158 feet, with a descent of the different parts of Niagara River reaching 326 feet.

During the long, earlier history of Niagara, there were at first two, and later, three, separate cataracts. The upper two united when the Falls had receded about three miles; the third joined the others later, but it had no effect on the recession of the main Falls, as it was soon reduced in height by the backing of the waters of Lake Ontario.

Until this time, when the Falls had passed the point of union by only 600 feet, the volume of the river was 15 per cent. of the modern size. Now it was increased to 100 per cent., breaking through the floor of the cañon to a depth of 135 feet, which the united cataracts had not been able to do before the increase in the volume of the Falls. This augmentation resulted from the accession of the drainage of Lakes Huron, Michigan, and Superior, which formerly drained to the north-east, and only now joined the Lake Erie discharge, for until this time Niagara received only the drainage of Lake Erie. This change was due to a tilting of the earth's crust, which culminated only 3,500 years ago.

The Upper Rapids are due to the river recently reopening a buried valley and descending over its eastern slope. This valley, however, did not trend northward, but southward. Accordingly, the Upper Rapids have had little to do with the recession of the Falls.

Thus it appears that the rate of recession has been modified by changes of volume and of height. These features, and the character of the rock-formation, as well as the buried valleys, I now know for every furlong which the Falls have receded. If we apply the laws of erosion to these changing features the result will indicate that the time required for the recession of the first three miles was 35,000 years; but for the last four miles only 3,500 years, which gives a total age of 39,000 years. As all the changing conditions are now known, it appears that the probable error does not exceed 10 per cent. This is the only computation of the age of the Falls which has been made upon measurements of all the changes in the physics of Niagara Falls, to which no other has had access.

Almost all of the physical changes in the history of Niagara Falls have been made by the writer, at different times. These, with the newly-found features, have now been brought together for the first time, and will form a monograph of the Geological Survey of Canada.

IV.—The Rotiform Bryozoa of the Isle of Wight.

By J. W. Gregory, D.Sc., F.R.S., F.G.S.

A SMALL fossil with a wheel-shaped body borne on a narrow stem has long been known from the base of the *Holaster planus* zone in the Isle of Wight. It has been recognized as one of the Bryozoa, but has not been described, although once recorded as "near *Defrancia diadema*, Hag."[1] It has also been recorded by Dr. A. W. Rowe as "the beautiful little rotiform Bryozoon."[2]

The following diagnosis has been lying unpublished for eight years in the manuscript of the second volume of the Catalogue of Cretaceous Bryozoa in the British Museum. A preliminary account of the species is now issued, as the name is wanted for reference in the course of Dr. A. W. Rowe's forthcoming memoir on the Chalk of the Isle of Wight. A fuller account of the species with illustrations, on plates drawn in 1900, will be given in the Catalogue, which it is hoped will be issued during this Winter.

Bicavea rotaformis,[3] n.sp.

Diagnosis.—Zoarium simple or compound, with a narrow cylindrical stem, attached in a circular concavity in the lower part of the body. The body of the zoarium is discoid, or wheel-shaped, and has on the margin a series of vertical radial projections like cog-wheels. The cogs usually project for a distance nearly equal to the radius of the disc. The cogs may be prolonged at their upper, outer corner into spike-like fasciculi. The upper surface between the bases of the fasciculi is depressed, and occupied by the small, crowded, irregular apertures of the intermediate, subordinate zoœcia. Stems appear solid and imperforate, as they are covered by a lamina, which is fluted vertically or wrinkled horizontally. Two zoaria may arise from one stem, or several zoaria may arise from a stolon.

Dimensions.	B.M. D. 2297.	B.M. D. 2296.
Diameter of body, central disc	3 mm.	3·5–3·75 mm.
Diameter of body, including projections	5 ,,	6–7 mm.
Length of stem	2 ,,	—
Diameter of stem	·8–1 mm.	1 mm.
Zoœcia, diameter	—	·15–·17 mm.
Zoœcia, diameter of aperture	·08 mm.	·08–·1 mm.
Number of fasciculi	—	8–9

Distribution.—Dr. Rowe has kindly given me the following list of localities. The horizon is always the base of the *Holaster planus* zone:—Dorset; Mupe Bay. Isle of Wight: Military Road, Freshwater; Pit No. 13, Shalcombe Down; Pits Nos. 19 and 20, Arreton Down; Pit No. 37, Brading Down; Pit No. 51, Carisbrooke; and at Compton Bay and Culver Cliff.

Affinities.—The nearest allies of this species are some specimens from the Danian Chalk of Faxoe described as *Radiopora urnula*,[4]

[1] H. W. Bristow: "Geology of the Isle of Wight," 2nd ed., 1889, p. 272.

[2] A. W. Rowe: "The Zones of the White Chalk of the English Coast.—II. Dorset": Proc. Geol. Assoc., vol. xvii, pt. 1, 1901, pp. 23, 46.

[3] Shaped like a cog-wheel.

[4] *Radiopora urnula*, Pergens & Meunier: Bry. gar. Faxe: Ann. Soc. mal. Belg., vol. xxi, pp. 224–226, pl. ix, figs. 1–5; pl. x, fig. 6.

var. *stipitata*, by Pergens & Meunier in 1887; the authors divided that species into three varieties, of which the form *stipitata* has a narrow stem and discoid head like the English specimens. Some workers at Bryozoa would no doubt include the Danian, the French Maastrichtian, and the British Turonian varieties as all members of one species, which would then have the name *B. urnula* (d'Orb.).[1] But the differences between the specimens from these three horizons seem adequate for their specific separation. The *B. urnula*, the type species of the genus, has a vasiform body, which is convex below and passes gradually into the short stem, while the apertures of the zoœcia are on tufts or radial keel-like plates projecting above the body. *B. rotaformis*, the oldest representative of the genus, has a wheel-shaped body on a narrow stem, and the apertures are on vertical teeth on the sides of the body. The Danian forms are very variable in form; the stem is longer and narrower than in *B. urnula*, but it still passes by a gradual expansion into the body; the usual form of the zoarium is more piriform than in *B. rotaformis*. Further differences are that in the Danian forms the stem is perforate, and the apertures of the zoœcia open on ridges which project but slightly from the disc; in one specimen of var. *stipitata* one of the ridges projects upwards as one of the spine-like processes so characteristic of the genus. Though *B. rotaformis* is variable, the lower side of the body is apparently always concave, whereas in the Danian forms—which I regard as a new species with the name *B. pergensi*—and in *B. urnula* the base is always concave. Both Dr. Rowe and Mr. C. D. Sherborn, who have collected a considerable number of specimens of *B. rotaformis*, tell me that they have not seen one with a vasiform body, and my more limited experience has been the same.

V.—On an African Occurrence of Fossil Mammalia associated with Stone Implements.

By F. P. Mennell, F.G.S., and E. C. Chubb, F.Z.S., of the Rhodesia Museum, Bulawayo.

STONE implements have long been known to occur in South Africa, but nearly all the recorded discoveries have, until quite recently, been made at the Cape. Indeed, it is only lately that the subject has attracted much attention, and that the circumstances of their occurrence have been at all fully investigated. Even now there is little precise information on the point, and yet it is essential to the solution of the problems they present. For, as one of us has previously pointed out,[2] in attempting to ascribe to their proper source the stone implements found in South Africa, we are confronted with difficulties that are unknown in Europe. Not only has the country been inhabited down to the present day by tribes like the 'Bushmen' unacquainted with the working of metals, and whose origin probably long antedates the

[1] *Fasciculipora urnula*, d'Orbigny, 1850; Prod. Pal., vol. ii, p. 268. *Biscoea urnula*, d'Orbigny; Bry. Crét.; Pal. Franç., vol. v, 1854, p. 956, pl. 776, figs. 1–2.

[2] See Fourth Annual Report of the Rhodesia Museum (1904), which contains the first published descriptions of Rhodesian stone implements.

earliest Egyptian civilisation, but we find stone still employed by the Bantu for certain purposes, and in Rhodesia the question is still further complicated by the existence of numerous ruins built by an unknown race possessing a considerable degree of barbaric culture, but still employing primitive types of stone implements. Geological evidence is therefore more than usually necessary, but, when there is any, it is frequently very ambiguous owing to the characters of the superficial deposits. More often than not it is altogether lacking, the great majority of the implements found having been picked up on the surface. Colonel Feilden some time ago pointed out the probability of certain of the Zambezi implements being of vast antiquity,[1] and one of us had already formed a similar opinion in the course of a brief visit to the Victoria Falls. It is also probable that in other parts of Rhodesia the high-level laterites, corresponding to the plateau gravels of rivers like the Thames, are the source of the implements found where they occur, but, as in the case of the Zambezi, we are unable to afford absolute proof.

Many of the Rhodesian implements can with considerable confidence be ascribed to the Bushmen, from their being found in caves decorated with the well-known paintings of that primitive race. These paintings cannot usually be deemed of any great antiquity, but the fact that an implement is Bushman does not in any case prevent its being of considerable age, and it is not even any guarantee that it is not fully as ancient as the European palæoliths. And it need hardly be pointed out that all cave implements are not necessarily Bushman, as the caves may have had different occupants at different periods. But for conclusive proofs of antiquity, it is necessary for the relics of human occupation to be associated with animal remains. Such remains have so far been exceedingly rare in Africa, and the recent discovery in Northern Rhodesia of fossil mammalian bones which proved to be associated with stone implements is therefore of great interest. Several casual references to the matter have already appeared in print, and at the risk of being somewhat premature in our conclusions it has seemed advisable to publish the following notes on the occurrence so as to place on record what has been definitely ascertained up to the present. Our investigations have been chiefly based on specimens in the Rhodesia Museum presented by the Broken Hill Company, Mr. Franklin White, Mr. Marshall Hole, and others, as well as on other material for the opportunity of examining which we are indebted to Mr. White and Mr. F. G. Colvile.

The Rhodesian Broken Hill Mine is situated about 150 miles north of the Kafue River in North-Western Rhodesia. It contains extensive zinc and lead deposits, which have a prominent outcrop in the shape of two small hills or 'kopjes' rising out of a 'vlei,' or swampy flat. The surrounding country is chiefly limestone, which is associated, in proximity to the ore-body, with schistose rocks, evidently altered sandy and shaly sediments, together with crushed bands of the limestone itself. There is granite not many miles distant, but the ores do not appear to have any direct connection with an igneous

[1] *Nature*, vol. lxxiii, p. 77.

rock; they seem rather to be related to faulting and shearing of the limestone at its junction with the schists. Surface specimens of the limestone are usually somewhat coarsely crystalline, and white or grey in colour, with few impurities save quartz. Lower down in the workings they are often black or reddish in colour, and closely resemble the Carboniferous Limestone of Somersetshire. Under the microscope, however, they differ *in toto*, having a foliated structure in even the most compact-looking specimens. It is probable, therefore, that the sugary appearance of the outcropping rock is due to some form of surface alteration. It cannot be attributed to pressure or contact metamorphism, as it would in that case be just as apparent below ground as it is above. The limestone is highly magnesian and sometimes approaches a true dolomite in composition. No definite silicate minerals can be detected under the microscope.

The feature of the ore-body with which we are now chiefly concerned is the extraordinary accumulation of mammalian bones in No. 1 Kopje. Beautifully crystallised phosphatic minerals have also been found in No. 2 Kopje, but although it would seem a natural inference that they are due to the interaction of the metalliferous solutions with the lime phosphate of bones, none of the latter have been met with. The amount of bones in No. 1 Kopje is enormous. They occur in the central part of the kopje and almost continuously beneath it, below the level of the surrounding flats. It would appear that the bone deposits represent the infilling of a large cavern in the limestone, perhaps with a kind of swallow-hole leading down from the top of the kopje, though there is no actual opening at the present time. It is difficult from the data at present available to determine with any certainty the relative ages of the different layers of bones, but their accumulation must have taken a very long period of time. There are masses of bones almost free from other substances, and there are interspersed muddy layers containing zinc compounds, but free from bones. Much of the material, however, which shows no large bones, yields on disintegration innumerable bones of rats, shrews, birds, etc. The bones are in nearly all cases partly or wholly converted into zinc phosphate (hopeite?). They are therefore truly fossil, the organic matter having disappeared, and having been completely replaced by mineral substances. Vughs in the deposit are often lined with magnificent crystals of the rare mineral hopeite, and they also show at times more or less dendritic coatings of a substance which at first was taken for amorphous zinc phosphate, but which is rich in vanadium, and may really be a calcium vanadate. The new triclinic zinc phosphate 'tarbuttite' occurs in No. 2 Kopje, with cerussite, hemimorphite, hopeite, pyromorphite, and vanadinite or descloizite, and does not seem to be found in the bone deposit.

The bones make up vast accumulations of isolated broken fragments. Whole bones are the rarest exceptions, and are exceedingly difficult to extract even when discovered. There never appear to be a number of bones belonging to the same animal occurring together, as would be the case if they had died naturally on the spot, or been accidentally engulfed, in the way suggested for the well-known occurrence at the Winnats, Castleton, Derbyshire. It

seems certain that the deposits as a whole represent the materials accumulated during alternating occupations of the original cavern by animals and human beings, with intervening periods when the cave was untenanted owing probably to flooding with water. The animal occupants were such as are found together in the Rhodesian caves of the present day, namely, hyænas and porcupines, no doubt accompanied by owls and bats. Some of the bones show signs of having been gnawed by hyænas, and there can be little doubt that many of them were dragged into the place when it served as a hyæna den. Most of the smaller bones are probably to be accounted for in a somewhat similar fashion, the rats, shrews, etc., having formed the prey of owls, and the bones having been ejected in the usual pellets after the birds had assimilated the more digestible portions of the bodies. An examination of modern owl pellets entirely confirms this view, as these latter show the same predominance of head and leg bones as do the washings of the Broken Hill deposit. As usual with mammalian remains, lower jaws are particularly prominent. Those parts of the deposit which contain implements no doubt owe their accumulation in great part at least to human agency, the bones being relics of the food supply of the ancient inhabitants. It may at once be stated that the contemporaneity of the implements and bones is entirely beyond question. Masses of the deposit full of bones when disintegrated by soaking in water, are found to contain embedded implements. These latter are of a rude order and mostly made of quartz, owing of course to the absence of any more suitable material in the vicinity. There seems to be a strong prejudice in England against the genuineness of implements made of quartz, and it may therefore be well to emphasize the fact that some are made of chert brought from a distance, and it may also be well to point out that quartz is a very common material for Bushman implements, which the Broken Hill ones much resemble. Knives, scrapers, and grooved scrapers are the common types. Some of the bones show indications of having been cut previously to their mineralisation, as if to make implements, though no finished bone implements have so far been brought to light. One tibia of a moderate-sized ungulate in the Rhodesia Museum has had a nearly circular hole made in it prior to its replacement by zinc salts. This may be attributed to a wound from an arrow of the Bushman type, or it may have been bored with a view to making an implement or ornament: in either case it must be due to human agency.

With regard to the age of the deposit, it must represent a long period of time in all, but it will be noted from the subjoined list that nearly all the bones appear to be referable without much doubt to recent species inhabiting the country at the present day. It is probable, however, that some may represent closely allied but really ancestral forms, and this certainly appears to be the case with the species of *Diceros* (rhinoceros) of which two well-preserved bones are now in the Rhodesia Museum. It is unfortunate that we are not in possession of skulls or teeth of this animal, but we think there can be little doubt as to its being new, and it has therefore been thought well to give it a name for convenient future reference.

The mineral condition of the bones and the obvious changes in the

physical features of the locality since the deposit was formed are entirely in accord with the idea of its being of very great age from an anthropological point of view. There consequently appears to be every justification for our belief that the evidence affords the strongest presumption of the great antiquity of man in this part of the world, and that further investigations, which we hope shortly to undertake, will reveal even more convincing proof on this head.

LIST OF VERTEBRATE REMAINS.

[By E. C. Chubb.]

The following is a list of the vertebrates represented by teeth or bones, and identified as accurately as is possible with the scanty material at my disposal for comparison. "R.M." after a description indicates a specimen in the Rhodesia Museum.

MAMMALIA.

Insectivora.

An almost complete skull, two or three upper jaws, and numerous lower jaws of shrews. (R.M.)

Carnivora.

Felis leo, Linn. A right ramus and a few odd teeth.

Felis spp. The canine of an animal about the size of a leopard, and one about the size of *Felis ocreata*. Also two lower jaws apparently belonging to *Felis serval*.

Hyæna sp. A right ramus, belongs to a hyæna, but it does not agree exactly with *H. crocuta*. (R.M.)

Viverridæ. The right ramus of a member of this family about the size of a large genet.

Rodentia.

Tatera sp. Several upper and lower jaws. (R.M.)

Otomys sp. A number of lower jaws showing the characteristic laminated molars and grooved incisors. There are also one or two odd incisors and molars. (R.M.)

Mus spp. Great numbers of lower jaws and a few portions of upper jaws belonging to several different-sized species. (R.M.)

Bathyergidæ. A right ramus, without teeth, approximating to *Georychus capensis* in size. (R.M.)

Hystrix sp. A complete ramus and an odd incisor.

Ungulata.

Phacochœrus æthiopicus, Pall. A right upper tusk and a portion of an upper tusk, showing scraping and chipping by human agency. A lower tusk.

Elephas africanus, Blumen. The proximal portion of a humerus, and part of a scapula.

Diceros, Gray. Two complete bones, a left humerus and a right tibia, of a rhinoceros, excavated by Mr. Franklin White, were presented by him to the Museum. (R.M. No. 546.) On comparing these with bones of the modern *D. bicornis*, I find they differ so materially as to

warrant their recognition as belonging to a distinct species. This may be known, after the discoverer, as *Diceros whitei*, sp. nov.

Diceros whitei, sp. nov. The humerus of this species differs most remarkably from that of *D. bicornis* in the shape of its distal end. The olecranon fossa is very much narrower than in *D. bicornis*, being 29 mm. in diameter, as compared with 51 mm. for a specimen of the latter. Indeed, the whole bone, although evidently that of a fully adult individual, is smaller and much slighter in proportion to its length, which is 330 mm., from the trochlea to the head of the humerus, while *D. bicornis* measures 358 mm. The tibia, although not differing to the same extent as the humerus, is nevertheless slightly narrower in proportion, and a little shorter. This species is evidently a form of rhinoceros smaller and less heavily built than *D. bicornis*. For this reason it is also distinct from *D. simus*, and from *D. simplicidens*, Scott,[1] which is likewise larger than *D. bicornis*. I hope shortly to publish figures showing fully the differences between the species.

Equus sp. Several molars probably belonging to a zebra.

Connochætes taurinus, Burch. The basal portion of a horn-core.

Strepsiceros strepsiceros, Pall. An imperfect horn-core.

Taurotragus oryx, Pall. Portion of a horn-core.

In addition to the above there are in the Rhodesia Museum a number of bones and teeth of various other antelopes, not identifiable with certainty.

AVES.

An incomplete pelvis of a small bird, an ulna, and several leg-bones.

AMPHIBIA.

The ischial portion of a frog's pelvis; also an astragalus and calcaneum.

VI.—Iron Ore Supplies.

By Bennett H. Brough, Assoc. R.S.M., F.G.S., F.I.C.

OF all the problems with which the practical geologist has to deal, none is of greater importance at the present time than the discovery of fresh sources of iron ore supply. Every inhabitant of the United Kingdom, of the United States, and of Germany requires annually about a quarter of a ton of the iron of which the world last year produced 60,000,000 tons, the result of the smelting of over 120,000,000 tons of ore. Year by year the production and consumption are increasing, and many of the deposits of the richer ores are showing signs of depletion. The question of ascertaining how the demand for the vast supplies of iron ore that will in the future be needed will be met calls, therefore, for very serious consideration, and a few statistical notes may be useful as a contribution to a discussion of the subject.

[1] Third Rep. Natal Geol. Survey, 1907, p. 257. In employing the generic name *Opsiceros* for his species, Scott has overlooked a paper by Thomas in P.Z.S., 1901, p. 158, where it is shown that Gray's name *Diceros* antedates by twenty years *Opsiceros*, Gloger.

During the past half-century the development of the iron industry has been remarkable. In 1854 Mr. J. K. Blackwell showed that the world's production of pig iron did not exceed 6,000,000 tons, of which the United Kingdom produced 50 per cent., France and the United States each 12½ per cent., and Germany 6·6 per cent. In 1905 the world's production had attained the enormous total of 56,000,000 tons, of which the United States produced 42·7 per cent., Germany and Luxemburg 20 per cent., the United Kingdom 17·6 per cent., and France 5·5 per cent.

In Great Britain the principal iron-ore producing districts are Cleveland, in North Yorkshire, which in 1905 yielded 41 per cent. of the total output of the kingdom; Lincolnshire (14·8 per cent.), Northamptonshire (13·9 per cent.), and Leicestershire (4·7 per cent.), together yielding 33·4 per cent. of the total output; Cumberland (8·6 per cent.) and North Lancashire (2·7 per cent.), Staffordshire (6·1 per cent.), and Scotland (5·7 per cent.). The Cleveland iron ore occurs in a 10-foot bed in the Middle Lias, and contains about 30 per cent. of iron. It is worked by underground mining. In Lincolnshire, Northamptonshire, and Leicestershire the brown iron-ore beds form part of the Inferior Oolite, and contain about 33 per cent. of iron, the workings being mostly opencast. In Cumberland and North Lancashire the red hæmatite occurs in irregular masses in Carboniferous Limestone. It contains more than 50 per cent. of iron, and is worked by underground mining. The ironstone in Staffordshire and in Scotland is mostly obtained from mines that also produce coal.

Such, in brief, are the home deposits from which the British supply of 14,590,703 tons of iron ore, valued at £3,482,184, was obtained in 1905. Even that enormous output did not meet the consumption, and 7,344,786 tons were imported. Of that amount 78·5 per cent. was brought from Spain, 5·4 per cent. from Norway, 4·2 per cent. from Greece, 4·0 per cent. from Algeria, 2·6 per cent. from France, 2·6 per cent. from Sweden, 1·5 per cent. from Russia, and smaller quantities from Turkey, Germany, islands in the Pacific, Belgium, Newfoundland, India, Australia, Italy (Elba), Persia, Portugal, and other countries. In fact, the world is being ransacked for fresh iron-ore fields to supply ores for the British blast-furnaces. The port at which most of the ore was delivered was Middlesbrough (1,789,639 tons), then followed Glasgow with 1,042,179 tons, and then Cardiff with 875,462 tons.

While it is probable that the British iron-ore fields will be exhausted in a century or two, the outlook in other countries is similar. This is borne out by data relative to the available iron-ore supplies of the world which have been collected by Tornebohm for the Swedish Parliament, and, although largely conjectural, these figures are of great interest.

In the United States the iron-ore production in 1905 exceeded 42½ million tons, the highest output ever recorded, the ore containing more iron than the ores raised in Germany, in the United Kingdom, and in Spain combined. The bulk of the production was obtained in the Lake Superior region, where the five iron-ore belts or ranges (Marquette, Menominee, Gogebic, Vermilion, and Mesabi), beds of pre-Silurian age, have furnished since the beginning of regular mining

over 300,000,000 tons of iron ore. The average percentage of iron in the ore is 55, the 60 per cent. ores produced ten years ago having been exhausted by wasteful mining methods. The amount of ore still available in the United States is estimated by Torneböhm at 1,100,000,000 tons.

In Germany and Luxemburg two-thirds of the iron ore raised (23½ million tons in 1905) is derived from the so-called minette beds of Jurassic brown iron ore. The seams yield on an average 36 per cent. of iron and 1·7 per cent. of phosphoric acid. Owing to the high percentage of phosphorus the ore was of little value until 1879, when the basic method of making steel was brought into practical use by Thomas and Gilchrist. The amount of ore still available in Germany is estimated at 2,200,000,000 tons.

In Spain the chief deposits are near Bilbao, the ores, which are of great purity, occurring in beds of Cretaceous age. Up to the present time the Bilbao district has yielded about 115,000,000 tons of ore, and for many years pessimistic estimates have been made of the quantity of ore remaining. Twenty years ago it was thought that by the year 1900 there would be no ore left. Nevertheless, in that year Bilbao exported 5,000,000 tons of ore, and Don Julio de Lazurtegui, the most competent authority, estimated that there were still over 57,000,000 tons left. The richest red hæmatite ores are, it is true, now exhausted, and brown hæmatites and spathic ores have taken their place, with the result that more attention has to be paid to calcination and to the washing of ores to enable them to satisfy market requirements. Torneböhm's estimate of the quantity of ore still available in Spain is 500,000,000 tons.

In Sweden deposits of magnetite of great purity occurring in gneiss supply material for the charcoal blast-furnaces, and ores rich in phosphorus are mined for export at Grängesberg, in Central Sweden, and within the Arctic Circle at Gellivare, Kirunavaara, and Luossavara, where there are ample supplies to meet the increased demand that is likely to arise. These deposits have been described in great detail by Dr. Stutzer in a paper submitted at the last meeting of the Iron and Steel Institute. The export of iron ore from Sweden in 1905 amounted to 3½ million tons. In Northern Norway important discoveries of similar iron-ore deposits have of late been made. The amount of ore still available in Sweden is estimated at 1,200,000,000 tons.

In France the most important deposits are the beds of Oolitic iron ore in the department of the Meurthe-et-Moselle; and in Russia the greater portion of the iron ore produced is obtained from the Ural region, where, on the western side, the ores are chiefly limonite and spathic ores of a stratified character, and, on the east, masses of magnetite associated with igneous rocks. The amount of ore available in France is estimated at 1,500,000,000 tons and in Russia at the same amount. The available resources of other countries are estimated by Torneböhm at 1,200,000,000 tons. Including 1,000,000,000 tons for Great Britain, he estimates the known available resources of the world at 10,000,000,000 tons.

The outlook for the British industry is not altogether a depressing

one; for, whilst the rich ores of Bilbao and Elba are becoming scarce, there are still vast quantities of ore available in the north of Scandinavia, in the south of Spain, in Algeria, Canada, Cuba, Brazil, Venezuela, Chili, India, China (notably in the Shansi district), Australia, and South Africa. The high cost of carriage is, of course, an important factor; but the great economies which have and will be effected in transport will reduce this item. The future of the home demand is likely to be affected by the development of the basic open-hearth process of steel-making which enables phosphoric ores to be utilised. In the course of time such phosphoric ores will doubtless occupy a very prominent place in the manufacture of high-class steel. The development of magnetic concentration and of the briquetting of pulverulent ores for furnace use will render possible greater utilisation of poorer ores, while the development of the electric furnace will doubtless render it possible to utilise black sands and other titaniferous iron ores which, although met with in abundance, cannot at present be treated profitably in the blast-furnace. There need, therefore, be no immediate anxiety regarding the supply of the more impure iron ores, the application of which cannot fail rapidly to increase.

NOTICES OF MEMOIRS.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE: SEVENTY-SEVENTH ANNUAL GENERAL MEETING HELD AT LEICESTER, AUGUST 1ST, 1907.

I.—ADDRESS TO THE GEOLOGICAL SECTION. By Professor J. W. GREGORY, D.Sc., F.R.S., President of the Section.

(*Concluded from the September Number, p.* 418.)

IV. *Plutonists and Ore-formation.*—Belief in the earth's internal fires was most faithfully held amongst geologists by the Plutonists of the eighteenth century, and repudiated with equal thoroughness by the Neptunists, who refused to concede that volcanic action was due to deep-seated cosmic causes. Thus Jameson in 1807 stoutly maintained that volcanoes were superficial phenomena due to the combustion of beds of coal beneath fusible rocks, such as basalt, and that the explosions were due to the sudden expansion of sea-water into steam by contact with the burning coal. Volcanoes, according to this view, were correctly described as burning mountains, giving forth fire, flame, and smoke. The extreme Neptunist and Plutonist schools have long since been extinct, but the controversy is not quite closed. The battlefield is now practically restricted to economic geology, and the issue is the origin of some important ores.

Ore deposits present so many perplexing features that deep-seated igneous agencies were naturally invoked to explain them, and some of the most thorough-going champions of the igneous origin of ores make claims that remind us of the eighteenth-century Plutonists. The question is to some extent a matter of terms. Many of the ores which Vogt, for example, describes as of igneous origin he attributes,

not to the direct consolidation of material from a molten state, but to eruptive after-actions due to the hot solutions and heated gases given off from cooling igneous rocks. Igneous rocks probably play a notable part in the genesis of most primary ore deposits; for the entrance of the hot ore-bearing solutions is rendered possible by the heat of the igneous intrusions, as Professor Kemp has well shown in his paper on "The Rôle of Igneous Rocks in the Formation of Metallic Veins." Professor Kemp limits the term 'igneous' to materials formed by the direct consolidation of molten material; and this decision seems to me to be most convenient. For example, the quartzite that is so often found beneath a bed of basalt is due to hot alkaline water from the lava cementing the loose grains of sand; the process is an eruptive after-action, but it would be unusual to call such a quartzite an igneous rock.

1. *Igneous Ores.*—That there are ores which are the products of direct igneous origin is now almost universally admitted. The mineral magnetite is a most valuable source of iron, and it is a constituent of most basic igneous rocks. If iron were a high-priced metal, such as tin or copper, of which ores containing one or three per cent. are profitably worked, then basalt would be an ore of igneous origin. Under present commercial conditions, however, basalt cannot be regarded as an iron ore. But if the magnetite in a basic rock had been segregated into clots or masses large enough and pure enough to pay for mining, then they would be iron ores formed by igneous action. There are cases of such segregations large enough to be mined. The most famous is Taberg, a mountain in Smaland, near the southern end of Lake Wetter, in Sweden. It is a locality of historic interest: a view of it, as a mountain of iron, was published by Peter Ascanius[1] in the Philosophical Transactions in 1755, and Sefström discovered the element vanadium in its ore in 1830.

Taberg consists of an intrusive mass of rock composed of magnetite, olivine, labradorite, and pyroxene. Many theories of its formation have been advanced. The view generally adopted is that of Törnebohm, who described the rock as a variety of hyperite in which there has been a central segregation of magnetite to such an extent that some of it contains 31 per cent. of iron. Törnebohm claims to have traced a gradual passage from normal hyperite to a variety poor in felspar, then to one without felspar, and finally to a granular intergrowth of magnetite and olivine. This Taberg ore was mined and smelted for iron in the eighteenth century, when transport was more costly and commercial competition less keen than it is to-day. The ore has been worked at intervals as late as 1870; and as the hill is estimated to contain 100 million tons of ore above the level of the adjacent railway, it is not surprising that efforts are being again made to utilise the deposit, in spite of its low grade and high percentage of titanium. The Taberg hyperite has almost reached the line which divides magnetite-bearing rocks from useful iron ores. Its igneous origin, however, has not been universally accepted. The theory has been rejected by so eminent an authority as Posepny,

[1] Vol. xlix, pp. 30–34, pl. ii.

according to whom the ore occurs in solid veins as well as in grains; and he holds that, like other Scandinavian iron ores, it was due to secondary deposition. During a visit to the mountain I failed to see any secondary veins, except of insignificant value. The microscopic sections of the ore show that it is a granular aggregate of olivine, generally with labradorite and pyroxene. Hence I have no hesitation in accepting the view of the Swedish geologists and regard Taberg as a magmatic segregation. Posepny[1] has in this case carried his Neptunist theory of the genesis of ores too far.

At Routivaara, in Swedish Lapland, there is a still larger mass of magnetite, which is claimed, in accordance with the descriptions of Petersson and Sjögren, to be due to segregation from the magma of the surrounding gabbro. This mass of magnetite is of colossal size, but it is of no present economic value owing to its high percentage of titanium and its remote position.

An igneous origin is claimed by Professor Högbom for some small masses of titaniferous magnetite in the island of Alnö, opposite Sundsvall, on the eastern coast of Sweden. This case is of interest, as the surrounding rock is not basic: it is a nepheline syenite, containing only 2 per cent. of magnetite, which, however, has been concentrated in places, until some specimens (according to an analysis quoted by Professor Högbom) contain as much as 64 per cent. of magnetite, 9 per cent. of ferrous oxide, and 12 per cent. of titanic oxide.

The Alnö magnetites, again, are of no practical value, as they are too low in grade and too refractory in nature. I understand that about 500 tons of the material have been smelted, but with unprofitable results, and the rest of the material quarried has been left on the shore. We may therefore accept the iron-bearing masses of Alnö and Routivaara, as well as that at Taberg, as due to magmatic segregation, without having conceded much as to the igneous formation of ores. The process in this case has formed rocks, rich in titaniferous magnetite, from which iron could be obtained, but rocks which no ironmaster is at present willing to buy as iron ore. Whether a basic igneous rock is to be regarded as an iron ore, or as only useful for road metal, depends on cost of treatment. The definition of the term 'ore' is very elastic. Petrographers speak of the minute grains of magnetite or chromite in a rock as its ores; but that is a special use of the term 'ore.' Usually ore means a material which can be profitably worked as a source of metals under existing or practicable industrial conditions.[2] According to this definition, the Swedish deposits of titaniferous magnetite are at present doubtfully within the category of iron ores.

The famous iron mines of Middle Sweden at Dannemorra, Norrberg, Grangesberg, and Persberg occur under different geological conditions; they work lenticles or bands of ores in metamorphic rocks, of which

[1] F. Posepny, "The Genesis of Ore Deposits": Trans. Amer. Inst. Min. Eng., 1893, p. 323.

[2] The Oxford Dictionary adopts a still more restricted definition: according to it an ore is "a native mineral containing a precious or useful metal in such quantity and in such chemical combination as to make its extraction profitable."

some are altered sediments; and the view has therefore been held by de Launay and Vogt that the ores also are altered sediments.

That ores are formed by igneous segregation of sufficient size and purity to be of economic importance is a theory which rests on two chief cases—the nickel ores of Sudbury in Canada and the iron ores of Swedish Lapland.

2. *The Sudbury Nickel Ores.*—The nickel ores of Sudbury are the most important historically. They have been repeatedly claimed as of direct igneous origin by Bell (1891), von Foullon (1892), Vogt (1893), Barlow (1903), and by other geologists; and his view was advocated before the Association at the Johannesburg meeting by Professor Coleman. The theory was stoutly opposed by Posepny in 1893, and Professor Beck in 1901 described some of the brecciated ore, and showed that its metallic minerals are sharply separated from the barren rock. He held that such ore must have been formed, not only after the consolidation of the rock, but even after or during its subsequent metamorphism. The views of Posepny and Beck seem to have been established by additional microscopic study of the ores by C. W. Dickson (1903). He has shown that the sulphides are separated from the barren rock by sharp boundaries, and without any indication of a passage between them; that the fragments of ore in the rock have short corners, whereas, had they grown in a molten magma, the angles would have been rounded and the faces corroded. Most of the ore, moreover, occurs as a cement filling interspaces between broken fragments of barren rock and along planes of shearing. The Sudbury ores, therefore, appear to have been deposited from solution during or after the brecciation of the rocks in which they occur, and long after their first consolidation. If Dickson's facts be right, the Sudbury ores are necessarily aqueous and not igneous in origin.

3. *Scandinavian Iron Ores.*—The other important mining field of which the ores are claimed as of igneous origin is Swedish Lapland. Its ores are rich and the ore bodies colossal. One mine, Kirunavaara, yielded over one and a half million tons of ore in 1906, and according to a recent agreement with the Swedish Government the annual output of ore from that mine may be raised to three million tons by 1913.

The chief mining fields of Lapland, although situated to the north of the Arctic Circle, have long been known, for some of them contain veins of copper which were worked, for example, at Svappavaara in the seventeenth century. The iron ores, however, could not be used until a railway had been laid through the swamps of Lapland to carry the ores cheaply to the coast. In 1862 an ill-fated English company began a railway to the Gellivara mines, and thirty years later this was completed across Scandinavia, from the head of the Gulf of Bothnia at Lulea to an ice-free port at Narvik, on the Norwegian coast.

This railway, the most northern in the world, passes the two great mining fields of Gellivara and Kiruna. The mining field of Kiruna is the larger and at present of the greater geological interest, as its structure is simpler and its rocks less altered.

The ore body at Kiruna outcrops along the crest of a ridge two miles long, and it is continued beneath Lake Luossajarvi to the smaller but

still immense ore body of Luossavaara. At Kiruna the ore rises to the height of 816 feet above the surface of the lake, and it varies in thickness from 30 to 500 feet, with an average thickness of about 230 feet. According to the report by Professor Walfrid Petersson,[1] submitted this year to the Swedish Parliament, Kirunavaara contains 200 million tons of ore above lake-level, and Luossavaara another 22½ million tons. The ore is high-grade. According to Lundbohm 60 per cent. of the trial pits showed a yield varying from 67 to 71 per cent. of iron, and 21 per cent. of them showed a yield of from 60 to 67 per cent. of iron. The average of nineteen analyses published in Professor Petersson's recent report gives the contents of iron as 64·15 per cent. Unlike the Taberg and Routivaara ores, the percentage of titanium is very low; thus in nineteen analyses given by Petersson the average of titanic acid is only ·23 per cent., and it varies in the specimens from ·04 to ·8 per cent.

The ore lies between two series of acid rocks, which have been very differently interpreted, but will no doubt be fully explained by the researches now in progress under the direction of Mr. Lundbohm. The rocks were first called halleflinta, as by Fredholm, and regarded as of sedimentary origin. They are now accepted as an igneous series, associated with some conglomerates, slates, and quartzites. The ore body itself is bounded on both sides by porphyrites, of which that on the lower or western side is more basic than that overlying the ore to the east. The basic western porphyrite is in contact with a soda-augite syenite of which the relations are still uncertain. Interbedded with the overlying eastern porphyrite are rocks that appear to be volcanic tuffs, and both in the tuffs and in the upper porphyrite are fragments of the Kiruna ore.

Three main theories of the genesis of the Kiruna ores have been proposed. Their sedimentary origin was urged on the ground that they occur regularly interstratified in a series of altered sediments, and that the ores, therefore, are also sedimentary. This view may be promptly dismissed, since the adjacent rocks are igneous.

The second theory has been advanced independently by Professor de Launay and Dr. Helge Bäckström: according to them the porphyrites above and below the iron ores are lava-flows, and the ore was a superficial formation deposited in an interval between the volcanic eruptions. According to de Launay the iron was raised to the surface as emanations of iron chloride and iron sulphide; the iron was deposited as oxide, and most of it subsequently reduced to magnetite during the metamorphism of the district.

The third theory—that the ores are of direct igneous origin—has been maintained by Löfstrand, Högbom, and Stutzer; according to them the ores are segregations of magnetite from the acid igneous rocks in which they occur. The segregation theory has been opposed, amongst others, by de Launay and Vogt. Thus, de Launay maintains that the segregation would have been impossible in such fluid lavas as the Kiruna porphyrites, and is improbable, since there is no transition between the ore and the barren rock.

[1] *Bihang till Riksd. Prot.*, 1907, 1 Saml., 1 Afd., 84 Häft, No. 107, pp. 213, 217.

The segregation theory has serious difficulties, and is faced by several obvious improbabilities. The ore occurs as a band nearly forty times as long as it is broad. It has the aspect, therefore, of a bed or a lode. The ore has not the granular, crystalline structure of an igneous rock like the hyperite of Taberg, but the aspect of a material deposited from solution or formed metasomatically. It is almost free from titanium, the undesirable constituent so abundant in the ores of Taberg and Routivaara.

The igneous theory cannot, however, be lightly dismissed, as it is supported by the high authority of Professor Högbom, and therefore demands careful consideration.

It has been advanced in two main forms, the one considering the ore to have been deposited at the time when the igneous rocks are consolidating, the other considering it was deposited at a later period. According to Professor Högbom, the ore was syngenetic, being a true magmatic segregation from a syenite. But, according to Dr. Stutzer (1906), the segregation was later than the consolidation of the syenite. He describes the lode as an intrusive banded dyke, of which the chief constituents are magnetite and apatite; and the injection of this dyke pneumatolytically affected the rocks beside it, producing an intermediate zone impregnated with ore, which he compares to contact deposits.[1]

In spite of the high authority of Professor Högbom, I am bound to confess that the Kiruna ores do not impress me as of igneous formation. Their bed-like form, microscopic structure, and poverty in titanium are features in which they differ from those admittedly due to direct magmatic segregation. The microscopic sections that I have examined suggest that both the magnetite and apatite were deposited from solution and later than the consolidation of the underlying porphyrite, which the ore in part replaces. An examination of the field evidence supports the conclusions of de Launay and Bäckström as to the ore being a bedded deposit overlying a lava-flow, but enlarged by secondary deposition.

V. *Future Supply of Iron Ores.*—This conclusion is perhaps economically disappointing. The possible existence of such vast segregations of iron in the acid igneous rocks has an important economic bearing. There is only too good reason to fear that the chief iron ores are comparatively limited in depth; for most of them have been formed by water containing oxygen and carbonic acid in solution, which has percolated downward from the surface. Ores thus formed are therefore restricted to the comparatively limited depths to which water can carry down these gases. On the theory, however, that these ores are primary segregations from deep-seated igneous rocks there need be no limit to their depth. They would

[1] In a later paper, of which only a short abstract has been issued, Dr. Stutzer, however, explains that "the intrusion of the ore dyke was at relatively the same time as the formation of the syenite, and that the ores were formed by magmatic separations *in situ*, or as peregrinating magmatic separations (magmatic veins and bedded streams)." He adds that "pneumatolysis plays no inconsiderable rôle in the formation of these veins." Dr. Stutzer's position may be summarised as regarding the ores as collected by segregation, but deposited in their present position by eruptive after-actions.

rather tend to increase in size downward, while maintaining, or even improving, in the richness of their metallic contents. For these bodies may be regarded as fragments of the metallic barysphere which have broken away from it and revolve around it like satellites floating in the rocky crust. On this conception these ore bodies would be of as great interest to the student of the earth's structure as their existence would be reassuring to the ironmaster, haunted as he is by constant predictions of an iron famine at no distant date. It is no doubt true that many of the richest, most accessible, most cheaply mined, and most easily smelted iron ores have been exhausted. The black-band ironstone and the clay iron-ores of the coalfields, which gave the British iron industry its early supremacy, now yield but a small proportion of the ores smelted in our furnaces. The Mesozoic beds of the English Midlands and of Yorkshire still supply large quantities of ore. Nevertheless the British iron industry is becoming increasingly dependent on foreign ores. So it would be pleasant to find that the Scandinavian iron mines are not subject to the usual limits in depth. I fear the typical iron deposits of Middle Sweden and of Gellivara will follow the general rule; but Kiruna may be an exception, and its ores may continue far downward along the surface of its sheet of porphyrite. The uncertainty in this case lies in the extent of the subsequent enrichment and enlargement of the bed; if most of the ore is due to secondary deposition, then it may be restricted to the comparatively shallow depths at which this process can act; and though that limit will be of no practical effect for a century or more to come, the ore deposit may be shallow as compared with gold-mines.

The geological evidence may convince us that all the economically important iron ores are limited to shallower depths than lodes of gold, copper, and tin; but this conclusion shall not enrol me among the pessimists as to the future of the iron supply. Twenty years ago a paper on the gold supplies of the world was read to the Association at the request of the Section of Economics. About the time that the report was issued there were sixty-eight mining companies with a nominal capital of £73,000,000 at work upon the Rand. Nevertheless, the author, accepting the view that "the future of South African gold-mining depends upon quartz veins," concluded: "There is as yet no evidence that the yield will be sufficient in amount to materially influence the world's production. As regards India, the prospect is still less hopeful."

That quotation may be excused, as it is not only a warning of the danger of negative predictions, but of the unfortunate consequences that happen when geologists are unduly influenced in geological questions by the opinions of those who are not geologists. In economic geology, as in theoretical geology, we should have greater confidence in the value of geological evidence. Negative predictions are especially rash in regard to iron, it being the most abundant and widely distributed of all the metals. The geologist who knows the amount of iron in most basic rocks finds it difficult to realise the possibility of an iron famine; he can hardly picture to himself some future ironmaster complaining of "iron, iron everywhere, and not

a ton to smelt." There are reserves of low-grade and refractory materials which the fastidious ironmaster cannot now use, since competition restricts him to ores of exceptional richness and purity. When the latter fail, an unlimited quantity could be made available by concentration processes. The vast quantities of iron ores suitable for present methods of smelting in Australia, Africa, and India show that the practical question is that of supplies to existing iron-working localities, and not of the universal failure of iron ores.

VI. *Mining Geology and Education.*—The genesis of ores and the extent of future ore supplies are intimately connected questions, and the recognition of this fact has led to the remarkable growth of interest in economic geology. This wider appreciation of the practical value of academic geology should, I venture to urge, be recognised among teachers by giving a more honoured place to economic geology.

It was inevitable that until the principles of geology had been firmly established, the detailed study of their application should have been postponed. Now, however, last century's work on academic geology enables the difficult problems connected with the genesis of metalliferous ores to be investigated with illuminating and practically useful results.

British interest in mining education has therefore been revived. Its history has been sadly fitful. Lyell,[1] in 1832, deplored the superiority of the Continent in this respect, as "the art of mining has long been taught in France, Germany, and Hungary in scientific institutions established for that purpose," whereas, he continues (quoting from the prospectus of a School of Mines in Cornwall, issued in 1825), "our miners have been left to themselves, almost without the assistance of scientific works in the English language, and without any 'School of Mines,' to blunder their own way into a certain degree of practical skill. The inconvenience of this want of system in a country where so much capital is expended, and often wasted, in mining adventures, has been well exposed by an eminent practical miner."

Though the chief British School of Mines made a late start, the brilliant originality of its professors soon carried it into the front rank; but in an evil day for the Mining School it was united with a Normal School for the Training of Teachers, now the Royal College of Science, and that school by its great success overwhelmed its older ally. Those interested in economic geology therefore welcome the recent decision to separate the technical from the educational and other courses, while leaving the Schools of Mines and Science sufficiently connected for successful co-operation. This policy should give such opportunities for the teaching of mining research that we may not always have to confess, as at present, that British contributions to mining geology do not rank as high as those made to other branches of our science.

Regrets are sometimes expressed, and perhaps still more often felt, at the tendency in scientific teaching to become more technical; but I, for one, do not fear evil from any such change. It is possible

[1] C. Lyell, "Principles of Geology," vol. i, 2nd ed. (1832), p. 63.

that the educational conflict of the future will be between academic science and technical science, on grounds in some respects analogous to those between classics and science during the last century. The advocates of the educational value of technical science are not inspired by mere impatience with the apparently useless, for they accept the principle that the essence of education is method, not matter. Therefore, they claim that the methods and principles of science can be better taught by subjects which are being used on a large scale in modern industries than by subjects of which the interest is still purely theoretical. Those who fear that academic science will be neglected if technical science be used in education may be encouraged by the brilliant revival of classical research since classics lost its educational monopoly. Academic science is even less likely to be neglected. It will always have its fascination for those intellectual hermits—shall I not say those saints of science?—who prefer to work for love of knowledge, free from the worrying intrusion of the mixed problems and fickle conditions of the industrial world; and the greater the progress of applied science the more urgent will be its demands for help from pure science, and, as a necessary consequence, the wider will be the appreciation and the more generous the endowment of scientific research.

Technical education must be as rigorous as that in academic education, and its connection with the fundamental principles must be as intimate. When so taught, economic problems provide at least as good a mental training as those branches of science which are purely theoretical. If the new Imperial College of Science and Technology carry on the mission for which the Geological Society was founded a century ago, if it inspire its students to have their delight in using past discoveries on the open surface of the earth, so that they may penetrate to what is within, then they will gain that sure knowledge of the formation and distribution of ores which is of ever-growing national importance.

II.—Some Desert Features.[1] By H. T. Ferrar, M.A., F.G.S.

CONTRAST between the deserts on either side of the Nile. The Western Desert, sometimes known as the Libyan Desert, presents all the features which one would expect to find in a region of deficient rainfall. There are broad featureless plains with no very definite drainage systems; there are long lines of sand-dunes stretching for tens of miles across the country; there are centripetal basins, and there are monadknocks or inselbergen, and an almost entire absence of vegetation.

The Eastern Desert, or the Etbai, on the other hand, displays an integrated drainage system; sand-dunes are conspicuous by their absence; vegetation is not scarce; and comparatively high mountains form a backbone to the country. These mountains are a true chain and form the water-parting between the Nile and the Red Sea. This water-parting is very much nearer the east coast, and, as in South Africa, so here we have the shorter and steeper eastward draining wadis

[1] By permission of the Director-General, Survey Department, Egypt.

beheading the longer westward drainages. The highest peaks usually consist of granite, which is sometimes foliated, and these high peaks, which rise majestically above the denuded schistose rocks, are not always on the actual watershed. Forms of rock and mountain sculptured by sandblast are not obvious, for the rain which occasionally falls destroys these and produces typical water-graded slopes.

The western desert surfaces consist of a thin veneer of waste, except where monadknocks or the escarpments of the oases display solid rock. This veneer of waste is protected, as in the Antarctic regions, by a layer of pebbles, which prevents the wind transporting the lighter material and prevents the rain-water from flowing in definite channels.

The eastern, or Etbai, desert shows bare hillsides, and the steep cliffs which form the wadi-walls are quite free from débris. The wadis or dry watercourses are at present being aggraded, and it is only in the wadi-beds that one finds the alluvium. This alluvium of boulders and rock-débris is usually from 5 to 50 feet in depth, and may be described as a torrential deposit. The only sorting of materials that is obvious in this region is that sorting due to water-action, where the volume of water and the slope of the ground are the determining factors.

Sorting of fine material from the coarse is not as common as one would expect. A high wind (Beaufort scale, force 8) will only move pebbles and grit less than 5 mm. in diameter, so that a succession of winds of unprecedented force would be necessary to produce 'pebble-beds.' The pebbles of the gravels on the western plateau, near Wadi Natrum, are all rounded and water-worn, and form a heavy mantle over the land which prevents the wind from picking up the lighter material from below, which they protect. It is only those stones on the surface that are wind-etched or show the faceted form. These gravels were deposited during the pluvial period, immediately preceding the present arid one, and therefore it would seem that the only reliable test to prove that a deposit was a desert formation would be to find in it tetrahedral and wind-etched stones.

Photographs were exhibited to show some of the points referred to in this paper.

III.—The Origin of the Upper Keuper of Leicestershire.[1] By T. O. Bosworth, B.A., F.G.S.

The Condition of the Rocks beneath the Keuper.—The Charnian igneous rocks beneath the Keuper are comparatively fresh right up to their surfaces, but where the marl has been denuded and the rocks are exposed to the present climate they are decomposed.

The Surface Features of the Rocks beneath the Keuper.—Smoothed, fretted, and curiously carved surfaces are seen at Mount Sorrel, Croft, Sapcote, Groby, etc., and usually wherever the marl rests on igneous rocks. They are often pitted and sometimes highly polished (e.g. at Narborough). But where the rocks are cleaved or broken, as

[1] Professor Watts, Geographical Journal, June, 1903.

at Swithland and Bardon, the floor beneath the Keuper is rough and craggy.

The Nature of the Deposits.—Everywhere the beds dip in the direction of the surface slopes on which they lie, and the amount of dip depends upon the steepness of the slope. Catenary bedding is seen at Croft and Groby. Near the rocks the marl contains grit and stones, and there is generally a breccia at the base. The stones are of varied sizes, sometimes worn and sometimes very angular. They are in a remarkably fresh condition.

Both stones and grit are derived entirely from the particular rocks which the beds containing them surround. In these beds there is often a small amount of quartz sand, sometimes apparently wind-worn. It yields the same heavy minerals as the Upper Keuper Sandstone.

In many cases, e.g., around the South Leicestershire igneous rocks, this sand cannot be of local origin.

At Croft some of the Upper Keuper Sandstone consists of almost spherical grains, and appears to be a desert sand.

Near Leicester the sandstone is uniformly false-bedded from the south-west, and *Estheria* and fish-scales occur upon the false-bedding planes. Heavy mineral separations have been prepared from a large number of localities throughout the country. The mineral grains are generally very much worn. The most plentiful are garnet, magnetite, zircon, tourmaline, and rutile.

In the normal Keuper Marl bands showing false bedding, ripple-marks, and salt pseudomorphs are generally common.

But such evidence of subaqueous deposition as there is points rather to the existence of occasional streams and salt pools than to the deep waters of one great Keuper lake.

It is inferred that the Upper Keuper is a desert accumulation.

IV.—The Relation of the Keuper Marls to the Pre-Cambrian Rocks at Bardon Hill. By W. Keay, Assoc. M. Inst. C. E., and Martin Gimson, Stud. Inst. C. E.

BARDON HILL is situated in the Charnwood Forest area, about ten miles north-west from Leicester. The hill rises to an elevation of 912 feet, and is higher than any of the land intervening between this point and the German Ocean.

The hill consists of Keuper marls resting unconformably upon Pre-Cambrian rocks, the latter protruding about 100 feet through the marls.

The object of this paper is—(1) To remark upon the unusual elevation of the Keuper marls. (2) To consider the probability of the entire submergence of the hill during the Triassic period.

1. *Elevation.*—Acting upon a statement of Professor Phillips that "the Triassic system offers the remarkable fact of never rising to elevations much above 800 feet," the authors by personal inspection, where possible, and by the aid of ordnance levels failed to discover any point on the Trias in England reaching a greater height than 800 feet except at Bardon Hill. Here, 'skerry' bands in the Keuper

marl may be seen at a height of 810 feet, and the marl may be traced in the fissures of the Cambrian rocks to a height of 880 feet. Hence the conclusion that the Keuper marls at Bardon reach an elevation at least as high and possibly higher than at any other point in the same strata in England.

2. *Submergence.*—The probability of Bardon Hill (912 feet), and therefore the whole Charnwood area, being entirely submerged during Triassic times presents itself as a problem.

The authors find at 810 feet two distinct 'skerry' bands resting upon, and overlain by, Keuper marl. In the Siberia Quarry the marl is found filling in two joints which rise nearly vertically a height of 80 feet. This 'filling' may be traced in the joints to a level of 880 feet, or 32 feet below the summit of the hill. There is no evidence suggesting the sudden termination of the marl at this level, but further tracing was prevented by vegetation. It is obvious that the marl must have been deposited from an elevation higher than 880 feet.

Further evidence in support of submergence is offered as follows:—The general dip of the marls in this district is from 1° to 3° S.E. Allowing an inclination of 1° only, or 90 feet per mile from a point at the junction with the Rhætics near Leicester, this would give (on the assumption that this inclination originally extended to Bardon) a covering of over 200 feet of marl above the present hill.

V.—On a hitherto unnoticed Section of the *Amaltheus spinatus* Zone and the Transition Bed in the Middle Lias at Billesdon Coplow, Leicestershire. By A. R. Horwood.[1]

THE author, after alluding to a section published by E. Wilson in the Geological Magazine, 1889, p. 296, of the Marlstone in the railway cutting at Tilton, Leicestershire, referred to a statement by that writer regarding it as the only exposure of the *Amaltheus spinatus* zone and Transition bed in the county.

Some recent researches, however, have resulted in the discovery of these beds in a little quarry on the road between Tilton village (some distance from the cutting quoted) and Billesdon Coplow, forming part of the escarpment called Life Hill, and about 700 feet O.D. There the very characteristic Gasteropod and Cephalopod zone of the Transition bed is well developed; and so uniform is this horizon in position and faunal contents that the author wished to see more stress laid on it than had previously been done, as indicating the uppermost beds of the Marlstone wherever found, being indeed a safe guide where other beds were wanting to denote this.

Another feature to be noted in the higher part of the Rock-bed, hitherto unnoticed or but little emphasised by previous writers on Liassic geology, was the occurrence of a very well-marked encrinital limestone band, varying from a foot to eighteen inches, though often less, of a very hard nature, less subject to the effects of weathering and decomposition than the Marlstone itself, which occurs some three or four feet lower in the section. This is to be found also on Tilton

[1] Read before Section C (Geology), British Association, Leicester, 1907.

Hill, indicating there also the existence of higher beds than previously known. Its composition was much like some forest marbles, entirely differing from that of beds above or below, though traces of a similar structure occurred less regularly, but never as a definite layer or seam, in other parts of the section.

The horizon of Wilson's type-specimen of *Eodiadema granulata* had never been definitely ascertained, nor indeed that of the majority of the Gasteropods, etc., described by him as coming from Tilton, but found in the débris used in the construction of the East Norton embankment.

The Billesdon Coplow section solved this question, for there the same Echinoderm was found with a number of the same genera and species of Gasteropoda, Cephalopoda, etc. It had also been found by others, and there was an example from Desborough in the Invertebrate Department of the Leicester Museum under the writer's charge.

In conclusion the author wished to reiterate his remarks as to the importance for zonal purposes of this Gasteropod band of the Transition bed of the Middle Lias.

The character of the fauna stamped it decidedly as purely littoral or coastal, whilst that of the beds below, containing as they did chiefly Brachiopoda and deeper-water Lamellibranchs and Cephalopods, pointed to their being of a more pelagic nature.

It marked a change in the physical conditions which predominated at that period, and as such was rightly named a 'Transition bed,' for the Upper Lias fauna was itself only a modification of it, with some differences of lithological composition in the strata and of species in the fauna which characterised it.

Probably the inset of more littoral conditions took place between the formation of the thick encrinital seam mentioned above and that of the Transition bed. Certainly pelagic conditions, judging from the lithology and fauna of the beds below, seemed to come to a close about the time when this encrinital seam was deposited.

The thickness of the strata and the fauna of the two sections, the one at Tilton as described by Wilson and the other as discovered at Billesdon Coplow by the writer, were, with some slight differences, due to local causes, more or less identical.

VI.—Notes on the Ancient Volcanoes of Basutoland. By Rev. S. S. Dornan.

Basutoland is a high plateau between the Vaal and the Orange Rivers. It is the culminating point of the great plateau which fills the whole interior of the sub-continent. Upon this plateau, as a foundation, stand the great volcanic ranges, more than 11,000 feet high.

From the Caledon River to the edge of the great volcanic plateau is about fifteen miles. This plain is fairly level, and is interspersed with flat-topped mountains rising to 1,500 feet above the plain. These represent the original level of the country. The geology of the country is exceedingly simple. It is filled with the Stormberg series, lying nearly horizontal. The total thickness of these rocks

amounts to 6,000 feet, of which the volcanic beds amount to 4,000 feet. The sandstones are loose and friable, and contain remains of plants, dinosaurs, and crocodiles.

The volcanic beds are the most striking rock features of the country, as they compose all the highest summits of the great ranges of mountains known as the Drakensberg and Malóte.

The vents from which the lavas and ash proceeded which have built up these great piles of rock can be roughly arranged in three or four parallel lines, corresponding to the present ranges of mountains. The first range consists of Machache, Thaba 'Telle, etc.; the second of Dikolobeng, Mokhele, etc.; the third of Mount Hamilton and Motai; and the last of the great summits of the Drakensberg, such as Mont aux Sources, Champagne Castle. Most of these mountains are 10,000 feet high and upwards. The rivers run in the synclines between these ranges of mountains, as a glance at the map shows.

The volcanic beds consist of lavas and ashes, with occasional silicious tuffs, intersected with intrusive sheets and dykes. Most of the lavas are amygdaloid; scoriaceous varieties also occur, but they are much less common. The beds are often full of pipe-like vesicles, filled with calcite, but often empty. These vesicles are inclined towards the vent. Basaltic lavas are common, and andesites also occur.

A short description of four of the most prominent peaks will serve as examples of the others.

(1) Thaba 'Telle. It is about 7,800 feet high, with steep—in some places precipitous—sides. It is composed of doleritic amygdaloid lavas, alternating with beds of ash. The plug is agglomerate, evidently the remains of the old throat. The lavas are full of steam holes. Thick deposits of purple ash also occur. Near the base of the mountain is a large intrusive sheet, surrounding what was formerly a subsidiary cone, but is now nothing more than a mere conical plug of agglomerate.

(2) Thaba Tsuen. This mountain is slightly lower than the preceding, but of beautiful conical shape. The height is 7,529 feet. It consists of two terraces and the agglomerate plug. The total thickness of lavas, ashes, and agglomerate is 1,600 feet. The plug proper rises from the second terrace, which slopes gently inwards, indicating the roots of the old cone. The plug is composed of coarse doleritic lava and agglomerate, and is about 500 feet high. It is a prominent landmark, and even more typically volcanic than many of the other peaks. The deposition of the lavas was not continuous, as there are thin intercalated beds of sandstone. The same feature occurs on all the other mountains examined.

(3) Thaba de Noha. This is a portion of the great Mokhele range. The plug and a portion of the old crater walls remain. The lavas at one point are glassy and steeply inclined, at another scoriaceous. There are also thick beds of ash. The characteristics of the lavas in this range are similar to the peaks previously mentioned.

(4) Thaba 'Ntso. This mountain is 7,560 feet high. It is part of a great range running perpendicular to the course of the Orange River. The composition of the lava beds is similar to Thaba de

Noha, the principal difference being that the beds of ash are thicker and better consolidated, evidently pointing to deposition in deeper water.

Many of the very highest peaks, such as Mont aux Sources, Motai, Mount Hamilton, are not described here, as the writer has never been able to visit them.

A short notice of the intrusive sheets and dykes is a necessary complement to the description of the lavas. These dykes, etc., are posterior to the volcanic beds which they traverse. None, so far as the writer knows, have the characteristic of a lava-flow.

They vary much in size, from a few inches thick and a few yards long up to 20 feet or more in thickness and several miles in length. Two remarkable examples of the latter kind occur in South Basutoland, near Mohales' Hoek. The dolerite is columnar, and as straight as if laid out artificially. Small displacement of the neighbouring strata is a conspicuous feature of these dykes.

The country owes its present configuration to two series of earth movements — one from west to east and the other from south to north, long afterwards. There is no evidence of denudation before the deposition of the lavas, and the writer is of opinion that the lavas were not all subaqueous.

VII.—Life-Zones in the British Carboniferous Rocks.[1]

THE part of the Report for 1906 which deals with the Carboniferous zones in Flintshire was founded on work done by Dr. Hind and Mr. Stobbs. Their conclusions were presented in a paper read before the Geological Society of London on April 4th, 1906. The Committee are not unanimously in agreement with some of the conclusions. On reference to the Abstr. Proc. Geol. Soc., No. 827 (1906), pp. 88–92, it will be seen that differences of opinion exist both as to the sequence and classification of the Carboniferous rocks of Flintshire.

In 1895, at the meeting of the Association at Ipswich, a paper was read before Section C by Messrs. Garwood and Marr in which they suggested "that a Committee be appointed to inquire into the possibility of dividing the Carboniferous rocks into zones, to call the attention of local observers to the desirability of collecting fossils with this view, and, if possible, to retain the services of eminent specialists to whom these fossils may be submitted."[2] As the result of that paper the present Committee was appointed at the same meeting.

Much has since been done, largely owing to the work of the Committee, and especially by the researches of Dr. A. Vaughan, whose well-known paper on the "Palæontological Sequence in the Carboniferous Limestone of the British Area" has in an eminently

[1] Report of the Committee, consisting of Mr. J. E. Marr (Chairman), Dr. Wheelton Hind (Secretary), Dr. F. A. Bather, Mr. G. C. Crick, Dr. A. H. Foord, Mr. H. Fox, Professor E. J. Garwood, Dr. G. J. Hinde, Professor P. F. Kendall, Mr. R. Kidston, Mr. G. W. Lamplugh, Professor G. A. Lebour, Mr. B. N. Peach, Mr. A. Strahan, Dr. A. Vaughan, and Dr. H. Woodward. Read before Section C (Geology), British Association, Leicester, 1907.

[2] Report British Association, 1895 (Ipswich), p. 696.

successful manner shown the possibility of the task for the consideration of which the Committee was initially appointed.

The Committee in submitting this final report desire to place on record their appreciation of the energy and enthusiasm of their secretary, Dr. Wheelton Hind.

Report on the work done.—Mr. H. Bolton, in an admirable paper, brought before the Geological Society the work he had done on the fauna of a marine horizon at the base of the Bristol Coalfield, a work towards which a portion of the grant was applied some two years ago. His paper will doubtless appear in the Society's Quarterly Journal, and it is unnecessary to say more here.

Mr. Tait, collector of the Geological Survey of Scotland, has been examining the Millstone Grit succession east of Lancaster this Summer; and Mr. Watson, of Owens College, has been working in the upper part of the valley of the Nidd. It has not been possible to examine their collections in time for this report.

The Secretary was fortunate enough to secure a fine collection of plants obtained in an abortive attempt to find coal at Thirshfield, near Grassington, in the valley of the Wharf. The exact place of the sinking is lat. 54° 3′, long. 2° 2′, and the shales are stated to be those which occur below a bed of Millstone Grit.

Mr. Kidston has kindly examined the specimens for him, and the following list is the result :—

Sphenopteris elegans, Bgt.
Calymmatotheca Stangeri, Stur.
Rhodea Moravica, Ett., sp.
Sphenopteris sp.
Calamites Ostraviensis, Stur.
Calamites sp.
Sphenophyllum tenerrimum, Ett., sp.
Lepidodendron sp.
Lepidostrobus sp.
Small Lycopodiaceous bract.
Rhabdocarpus (?) sp.

Mr. Kidston states, with regard to the horizon: "I have not the slightest doubt that the bed these specimens come from is on the horizon of the Upper Limestone group of the Carboniferous Limestone Series of Scotland." At any rate, we know that the Lower Limestone group of Scotland has a fauna which indicates the Upper *Dibunophyllum* zone.

VIII.—The Faunal Succession in the Carboniferous Limestone of the South-West of England.[1]

THE work has progressed steadily, but less rapidly than was anticipated owing to the necessity which has arisen of investigating the validity of certain genera and the correct application of specific names.

1.—*The Avonian Sequence in Gower.*

The zoning of the Avonian sequence of the Gower Peninsula, undertaken in conjunction with Mr. E. E. L. Dixon in the Summer of 1905, is now completed, and the results will be presented to the Geological Society early next session.

[1] Report of the Committee, consisting of Professor J. W. Gregory (Chairman), Dr. A. Vaughan (Secretary), Dr. Wheelton Hind, and Professor W. W. Watts, appointed to enable Dr. A. Vaughan to continue his Researches thereon. (Drawn up by the Secretary.) Read before Section C (Geology), British Association, Leicester, 1907.

In this investigation the chief interest, from a zonal standpoint, centres in the occurrence of a higher faunal level than is known from any other point of the South-Western Province. The level here referred to is that of the Oystermouth Beds, of which the well-known Bishopston rotten-stones are the degraded representatives. The list of genera from these beds is practically identical with that from the Upper Tournaisian—a fact which may be taken to imply equivalence of environment. Important conclusions as to variation in time during the Visean period have therefore been reached by comparing the several species of each genus at the Oystermouth level (uppermost Visean) and those of the same genus in the Upper *Zaphrentis*-zone (Upper Tournaisian). The comparison of these two levels determines those characters of each genus which are indicative of old age; whereas the comparison of the Brachiopods (or of the Corals) at one and the same level determines those characters which are affected by convergence.

Mr. Dixon's careful study of the conditions of deposition which are implied by the several lithic types increases very greatly the value of the zonal investigation by preventing the error of mistaking a change of fauna with change of conditions for a true zonal sequence dependent upon evolution.

2.—*The Carboniferous Sequence from Rush to Skerries, Co. Dublin.* (*In conjunction with* Dr. C. A. Matley.)

The stratigraphical relations have been admirably worked out by Dr. Matley, in spite of a quite remarkable intricacy of tectonic detail.

From a zonal point of view the main subject of inquiry is the true relative position of four distinct series whose sequence with one another is broken either by faults or gaps. The problem has been solved by a broad comparison of the coral faunas and their sequence in the South-Western Province. The relative position of the several portions has thus been established, and it has consequently become possible to draw up a detailed faunal sequence for the whole section. This sequence starts in the Upper Tournaisian, and extends beyond uppermost Avonian, being, however, notably incomplete in its middle portion.

The highest beds, which still exhibit an abundant Avonian fauna (the Upper *Cyathaxonia* beds), include a maximum of *Posidoniomya Becheri*, and at the same time contain several strikingly specialised forms of Corals and Brachiopods which also occur in the Lower Limestones of Scotland and in the uppermost Limestones of the western Midlands and Settle. Much light has thus been thrown upon the true correlation of the uppermost Avonian rocks in widely distant areas.

These results will be published at an early date.

3.—*Palæontological Work.*

The palæontological work arising out of these two papers has been very considerable, and is as yet incomplete.

Minute study of the material collected, and comparison with that already gathered from the South-Western Province and other British

localities, has shown the necessity of a re-investigation of the value of the characters upon which certain genera have been founded—e.g., the presence of a septum in Orthotetids, the existence of original fringes in Athyrids, the septation of Zaphrentids, etc.

I am also engaged upon the study of the types of Carboniferous Brachiopods preserved in the British Museum, and in this task Mr. S. S. Buckman has very kindly placed his long experience at my service.

I have also to acknowledge the great help which I have received from Mr. R. G. Carruthers in studying the Zaphrentids, and from many fellow-geologists who have sent me material for examination, and thus allowed me to keep in touch with the progress of research outside the areas in which I have myself worked.

So much remains to be done that I feel justified in asking for the continuance of this Committee for yet another year.

IX.—Note on a New Section in the Glacial Gravels of Holderness. By T. Sheppard, F.G.S., and J. W. Stather, F.G.S.[1]

THE North-Eastern Railway Company has recently been making some extensive excavations in a hill situated between the well-known Kelsey Hill and Burstwich Gravel-pits in Central Holderness. At the present time the section exposed is probably the finest of its kind in the country. The cutting is made through the heart of the hill, and the exposed section is 1,300 feet long and 45 feet high in the centre, from which the section gradually slopes. The sides of the hill are flanked by Boulder-clay, and irregular masses also occur at intervals in the gravel. There are two types of Boulder-clay visible, the upper or Hessle Clay, containing a preponderance of Cheviot rocks, and the purple or middle Boulder-clay with its Carboniferous limestones and basalts. The gravels are somewhat similar to those described by Mr. Clement Reid at Kelsey Hill as Interglacial, but the present authors consider them to be merely part of the terminal moraine of the North Sea ice-sheet. In addition to the far-travelled boulders, a lengthy list of marine shells, mostly of an Arctic type, has been compiled, and the species *Cyrena* (*Corbicula*) *fluminalis*, a fresh-water form, also abounds. An interesting collection of mammalian remains has been secured, and includes bones of *Elephas primigenius*, Rhinoceros, Walrus, Red Deer, *Bison priscus*, Horse, and *Bos*. Some of these bear evidence of having been gnawed by the Hyæna. It is thought that the shells and mammalian remains have been caught up by the moving ice mass, and in this way incorporated in the moraine.

X.—On a Marine Peat from the Union Dock, Liverpool.[1] By J. Lomas, A.R.C.S., F.G.S.

DURING excavations in the Union Dock on the Mersey Docks and Harbour Board Estate in the South End of Liverpool a very remarkable peat band was discovered. Reckoning downwards from a datum-line 3 feet above Old Dock Sill a section showed:—

[1] Read before Section C (Geology), British Association, Leicester, 1907.

	ft.	ins.
Sand with black carbonaceous bands	4	0
Peat	0	6
Blue clay with rootlets	4	0
Sand with thin bands of peat	2	10
Boulder-clay	3	2
Bunter pebble beds	8	0+

The upper peat was entirely composed of marine plants, laminaria predominating. On the fronds were numerous encrusting organisms, such as polyzoa, hydrozoa, the fry of young molluses, etc.

The lower peat, while consisting mainly of marine plants, contained a few drifted pieces of oak and other land plants.

The sands accompanying the peat resemble those of the Mersey Bar, and besides the quartz which makes up the bulk of the deposit, contain zircon, garnet, tourmaline, dolomite, kyanite, rutile, staurolite, orthoclase, felspar, biotite and muscovite, shell fragments, foraminifera, sponge spicules, and polyzoa.

The deposit was probably accumulated in a sheltered bay in the old estuary of the Mersey.

The chief interest lies in the fact that peat may be formed from marine as well as from land plants.

XI.—The Distribution of Radium in the Rocks of the Simplon Tunnel.[1] By Professor J. Joly, Sc.D., F.R.S.

THE principal classes of material which enter into the composition of the massif of the Simplon are: (*a*) The Jura-Trias sediments, lithologically often much alike and much interfolded: (*b*) the Palæozoic crystalline schists; and (*c*) the gneiss of Monte Leone and the Antigorio gneiss, both stated to be of Archæan age. These rocks throughout contain radium, and for the most part in quantities much above what hitherto has been ascribed to sedimentary or igneous rocks.

Some thirty-six typical samples, taken from various points in the tunnel, have been examined. The poorest in radium are certain anhydrite rocks. Certain amphibolite schists go very high. The Antigorio gneiss rises from $10{\cdot}5 \times 10^{-12}$ and $8{\cdot}0 \times 10^{-12}$ grams radium per gram of rock at the Italian entrance to $23{\cdot}7 \times 10^{-12}$ at 4,000 metres inwards. Some of the Archæan gneisses yielded very high results.

Such quantities of radium if generally distributed throughout the rocks of the massif would be sufficient to disturb any forecast of the temperature which under normal conditions would be encountered at the level of the tunnel. It is suggested that the radium was, in fact, the source of the discrepancy between the predicted and the observed rock temperatures.

As it is improbable that these results are unique and apply only to this particular sedimentary accumulation and locality, they appear to point to hitherto unsuspected quantities of radium (and its parent elements) in the immediate surface materials of the earth. It seems impossible to avoid the conclusion that these elements were precipitated

[1] Read before Section C (Geology), British Association, Leicester, 1907.

along with the sediments entering into the composition of the massif. The question then arises whether the accumulation of such quantities of radio-active elements may not enter as a factor in the events attending mountain-building. It can be shown that an area of sedimentation whereon has been accumulated some 10,000 metres of sediments, having a richness in radium comparable with the Simplon rocks, must necessarily become an area of greatly lessened crust-rigidity, and would hence become the probable site of crust-flexure under tangential compressive stress.

Further investigation will be required before such views can be generalised and the importance of radium as a source of instability of the earth's crust be determined. Apart from any speculations as to the influence of radium as the cause of an energetic substratum, the shifting of radium and its parent elements by denudation must be regarded as a convection of thermal energy, and this convection, if the quantities involved are sufficient, must, under the conditions referred to above and the unceasing action of denudation, become rhythmic in operation, and at the same time must result in shifting the areas of high temperature and crust-weakness from age to age as the site of sedimentary accumulation changes.

XII.—The Felsitic Agglomerate of the Charnwood Forest.[1] By F. W. Bennett, M.D., B.Sc.

THE rocks lying between the Beacon Series and the Blackbrook formation comprise a greater variety than has been hitherto recognised. Three main beds can be distinguished, which may be called the coarse, white, and pink grits. The pink grit, which is the uppermost bed, is the one to which almost exclusively the name of 'Felsitic Agglomerate' has been hitherto given.

Careful examination of the rocks in the Buck Hills has now conclusively proved that they belong to the Felsitic Series.

The rocks in the north-west of the Forest have always given rise to much difficulty. It is possible to trace the Felsitic Agglomerate as a distinct series of rocks in Timberwood Hill. The ground in this part of the Forest has been extremely faulted, and a good example of this occurs in Collier Hill.

To the north of the monastery, rocks have now been traced which evidently lie on the horizon of the Felsitic Series. They differ in some ways from the ordinary agglomerate type, especially as regards their texture, which becomes highly crystalline. It is found that these Felsitic rocks have been intruded into by igneous flows, both near the Cademan area and also in Bardon Hill; and it is probably due to this cause that the texture of the rock has been so much altered.

The position of these beds in relation to the Bomb rocks makes it probable that they correspond to the Felsitic Series, and this correlation is confirmed by comparison of some of the more recently discovered types with those of the ordinary Felsitic Agglomerate rocks.

[1] Read before Section C (Geology), British Association, Leicester, 1907.

XIII.—On the Occurrence of Boulders of Strontia in the Upper Triassic Marls of Abbots Leigh, near Bristol.[1] By Herbert Bolton, F.R.S.E., F.G.S.

A CONSIDERABLE area of the park attached to Leigh Court, near Bristol, has been found to be underlaid by a remarkable deposit of huge boulders of strontia embedded in Triassic marls. The boulders in various places appear above the surface. The soil varies in depth from a few inches to 4 feet, and rests upon the irregular surface of the marl-beds containing strontia. The boulders of strontia are found of all sizes, from a pea up to masses estimated at 100 tons in weight. In one instance the breaking-up of a single boulder of strontia occupied six men for five weeks. Six hundred tons of the mineral were found in one pit, 15 yards long by 21 yards wide.

The upper surface of the boulders is usually deeply grooved, the grooves running approximately north and south. The boulders readily split into slabs along lines coinciding with the grooves. The deposit up to the present has not exceeded a greater depth than 11 feet. The yield of strontia is about 2,000 tons per acre.

XIV.—Investigation of the Fossiliferous Drift Deposits at Kirmington, Lincolnshire, and at various localities in the East Riding of Yorkshire.[2] By J. W. Stather, F.G.S.

AS was intimated in our report for 1905, the work during the past year has been directed to the investigation of the deposit at Bielsbeck, or Bealsbeck, in the Vale of York, which was examined between seventy and eighty years ago by the Rev. W. V. Harcourt, and yielded the remains of numerous extinct mammals. The object of our investigation was mainly to ascertain if any further evidence could be obtained to show the relation of this fossiliferous deposit to the glacial drifts.

The work, which was carried out under the superintendence of Professor P. F. Kendall, Messrs. G. W. B. Macturk, Thomas Sheppard, and the Secretary, confirmed the statements of the previous observers: (1) that the deposits yielding the bones rested immediately on the Keuper Marl; (2) that they have been accumulated in a boggy hollow on an old land surface; and (3) that at this particular locality there is no material that can be assigned to the direct agency of ice. It therefore still remains a debatable question whether the bone-bearing material was accumulated before, during, or since the Glacial period; and it would appear that the elucidation of this matter will depend upon the investigation of a wide area to determine what was the condition of the Vale of York during that period.

[1] Read before Section C (Geology), British Association, Leicester, 1907.

[2] Report of the Committee, consisting of Mr. G. W. Lamplugh (Chairman), Mr. J. W. Stather (Secretary), Dr. Tempest Anderson, Professor J. W. Carr, Rev. W. Lower Carter, Dr. A. R. Dwerryhouse, Mr. F. W. Harmer, Mr. J. H. Howarth, Rev. W. Johnson, Professor P. F. Kendall, and Messrs. G. W. B. Macturk, E. T. Newton, H. M. Platnauer, Clement Reid, and Thomas Sheppard. (Drawn up by the Secretary.) Read before Section C (Geology), British Association, Leicester, 1907.

The absence of glacial deposits in this part of the country may, on the one hand, imply that the area was never glaciated; or, on the other hand, it may mean that glacial deposits once existing have been entirely removed. If the former be the case, the bone-bearing deposits might belong to the pre-Glacial or to any younger stage; while if the latter supposition should find confirmation the deposit must be later than the glaciation.

The site of the original excavation is still visible, the hollow from which the 'marl' was dug being now a reedy pond. The new sections consisted of four pits sunk in the vicinity of the pond.

These pits were roughly from two to four yards square, and were carried down until the Keuper Marl was reached or the work was stopped by the influx of water. They were supplemented by several boreholes put down to determine the extent of the deposit.

The sections revealed in the pits were as follows:—

Section 1.

	ft.	ins.
Surface soil	0	9
Sand, with small pieces of angular chalk and flint	2	0
Gravel of rounded chalk and subangular flint	1	6
Silty blue-black marl or loam, the upper surface very irregular and penetrated by 'pipes' and pockets of gravel from the bed above	3	9
Marl as above, with specks of vivianite	1	0
Black marl	6	0
Lighter-coloured marl, passing downwards into gravel (chiefly flints)	7	6
Total depth reached	22	6

Section 2.

Surface soil	0	9
Sand	1	9
Gravel	2	0
Dark silty marl, with gravel	2	6
Dark marl	4	0
Lighter marl	4	0
	15	0

Section 3.

Soil	1	0
Sand	2	0
Gravel	3	0
Grey marl, passing downwards into black	7	6
Coarse gravel	0	6
Solid Keuper Marl, blue	3	0
Solid Keuper Marl, red	1	0
	18	0

Section 4.

Soil	0	9
Sand	5	6
Gravel	1	6
Keuper Marl, its surface dipping at 1 in 3 towards the old marl-pit	1	3
	7	0

From the black muds or marls which occurred below the superficial gravels in these pits the following fossils were obtained:—

Bones.—For the following determination we are indebted to Dr. C. W. Andrews, F.R.S., of the British Museum (Natural History), South Kensington.

MAMMALIAN REMAINS.

Cervus sp.
Bos sp. (two vertebræ).
Bos sp. (smaller than *longifrons* or *primigenius*).
Bos primigenius.
Elephas (rib and left scapula).

The bones were not confined to any particular layer, but were distributed sporadically throughout the mass of the marl. The overlying gravels, however, contained neither bones nor other vestige of contemporaneous life, possibly because of their removal by percolating water.

Shells.—The molluscan remains distributed through the marl belong to existing land and fresh-water species, many of which are still living in the neighbourhood. They are all species of wide range, and afford no definite indications as to climate. These species, kindly determined for the Committee by Mr. J. W. Taylor, of Leeds, are as follows:—

MOLLUSCA.

Limnæa peregra.
,, *palustris*.
,, *truncatula*.
Succinea putris.
,, *elegans*.
Hyalinia nitidula.
Zonites fulvus.
Helix nemoralis.
,, *hispida*, var. *concinna*.
,, *pygmæa*.
,, *pulchella*.
Vertigo antivertigo.
,, *pygmæa*.
Cochlicopa lubrica.
Carychium minimum.
Pisidium amnicum.
,, *pusillum*.
,, *nitidum*.
,, *milium*.
,, *obtusale*.
Bythinia tentaculata.
Valvata cristata.
Planorbis spirorbis.
,, *contortus*.
,, *glaber*.
,, *marginatus*.

Plants.—The material also contained plant remains, but was difficult to wash and sift. Some small seeds were, however, picked out by Mr. Stainforth, and were submitted to Mr. Clement Reid, F.R.S., for determination, who recognised the following:—

SEEDS OF PLANTS.

Ranunculus sceleratus.
,, *repens*.
Viola sp.
Œnanthe aquatica, Poir.
Rumex.
Sparganium erectum?
Carex.
Alisma plantago.

With regard to the above list Mr. Reid remarks: "If these were all that were found at Bielsbeck, they are an exceptionally poor set, which shows nothing as to climatic conditions." "There are only one or two seeds of meadow plants among them, and no dry-soil plants."

Insects.—Besides the above the deposit contains the remains of beetles, but much of the material has not yet been specifically determined. The following may be mentioned:—

COLEOPTERA.

Donacia (sp.?) (an almost complete specimen).
Hister (sp.?) (elytron).

Further Notes on the Deposits.—The Bielsbeck bone-bearing deposits apparently occupy a depression or hollow in the Keuper Marl of undetermined width, and it appears as though this hollow is isolated and inclosed by the marl, though it is just possible that it may represent a portion of a filled-in valley or trench, the direction of which has not been traced.

Scattered through the marl at various depths were angular or slightly rounded black flints in large numbers, and these in some cases formed a definite layer. Along with the flints were occasional pebbles of quartz and of sandstone (probably Carboniferous). None of these pebbles showed striæ or other indication of glacial action.

The overlying gravel was mainly composed of flint and chalk from the neighbouring Wolds, along with scattered fragments of quartz, sandstone, etc. (like those found in the underlying marl), and *Gryphæa* and other fossils from the Lias. This gravel is the feather-edge of a wide fan which can be traced up to the mouth of a valley that drains from the Wolds at Market Weighton. In the thicker parts of this gravel, towards the mouth of the valley, other pebbles besides the above have been detected, including the well-known porphyrite which is characteristic of the upper part of the East Yorkshire drifts. The wide extent and depth of this gravel suggests that it has been spread out by floods from the melting ice, when the ice-margin abutted upon the eastern slopes of the Wolds. The present valley appears to be too short to supply a stream powerful enough to spread a sheet of gravel of these dimensions.

The thanks of the Committee are due to W. H. Fox, Esq., for permission to excavate; to the tenant, Mr. Howes; to Mr. W. H. Crofts; and to the contractor, Mr. Thomas Moate.

The Committee had contemplated work on another site in East Yorkshire, but have found difficulty in obtaining the requisite permission. Pending a final settlement of this matter, they ask for reappointment, with power to use the unexpended balance of their grant.

REVIEWS.

I.—Official Contributions to the Palæontology of South Australia. By R. Etheridge (Jun.)[1]. Records of Northern Territory Boring Operations. By H. Y. L. Brown, Government Geologist. Folio; pp. 22, with 12 plates. (Adelaide, 1907.)

IN continuation of the Northern Territory Report, No. 17 deals with Permo-Carboniferous fossils of Cape Dombey, etc. The only specimens capable of specific determination belong to *Aulosteges*, viz. *A. Baracoodeusis* (pl. i, figs. 1–5). This shows internal structure.

No. 18. Carboniferous fossils from Fossil Head, etc. A considerable series, including Brachiopoda, Pelecypoda, Gasteropoda, and Cephalopoda, are described and figured, namely:—

[1] [Mr. Etheridge being deceased, Mr. Robert Etheridge ceases to be 'Junior.' Edit. G.M.]

BRACHIOPODA.

Spirifera Musakheylensis, Davidson.
Orthotetes Pendiadabadensis, Eth., sp. nov.
Streptorhynchus?, sp. indet., cf. *S. Jukesii*, Eth.
Chonetes, sp. indet., cf. *C. Prattii*, Davids.

LAMELLIBRANCHIATA.

Aviculopecten? Hardmani, Eth. fil.
A. tenuicostilis, Dana.
Pteronites?
Merismopteria?
Nuculana Basedowi, Eth., sp. nov.
N. Waterhousei, Eth. fil. (var.).
Oriocrassatella Stokesi, Eth., gen. et sp. nov.

GASTEROPODA.

Trachomphalina humilis, de Kon., sp.
Bellerophon costatus, J. de C. Sby.
Bellerophon, var. *pauciatus*, Eth., var. nov.
Bucania Eucrii, Eth., sp. nov.

CEPHALOPODA.

Pleuronautilus? multicostatus, Eth., sp. nov.

No. 19. Fossils from the Port Keats bore, thirty miles north of Fossil Head. After passing through what may be Mesozoic beds, fossils of Permo-Carboniferous or Carboniferous age were obtained, including two Foraminifera, several species of Polyzoa, a coral (*Dybowskiella*), a Brachiopod (*Chonetes*), and leaves of *Glossopteris*; the more important are described and figured. They comprise:—

FORAMINIFERA.

Nubecularia Stephensi, Howchin.
Cornuspira involvens, Reuss (?).

ACTINOZOA.

Dybowskiella Gregi, Eth., sp. nov.

POLYZOA.

Ramipora sp.
Rhombopora Hindei, Eth., sp. nov.
Strebloteyga Browni, Eth., sp. nov.

Nos. 20, 21, and 22 deal with Cretaceous fossils from three localities, two of which are near Port Darwin. Plates are devoted to *Ancyloceras*, etc., though the genus is queried, and to *Ammonites Rhotomagensis*, which Mr. Etheridge says more resembles the British Chalk form than it does that from the Ootatoor group of Southern India. The species previously described from the Point Charles deposit (No. 20) and also obtained by Mr. H. Y. L. Brown and his party comprise:—*Aucella incurva*, Eth. fil.; *Nucula sejugata*, Eth. fil.; *Desmoceras cavolensis*, Eth. fil.; *Histriehoceras antipodeus*, Eth. fil.; *Scaphites cruciformis*, Eth. fil.; *Crioceras* (?) sp.; *Hamites* (?) sp.; *Ancyloceras* (?); *Belemnites* sp.

From No. 21, Shoal Bay, several of the same species of Cretaceous fossils were obtained, and in addition a specimen referred to the genus *Baculites* under the name of *Baculites Williamsoni*, Eth., sp. nov.

At locality No. 22, Maclear Creek, Cape Gambier, Melville Island, the common form *Inoceramus Etheridgei* was obtained, and an Ammonite (like our British form) named *Metacanthoplites Rhotomagensis*, Brongn.

Plates iii and iv. Typical blocks of groups of *Aviculopecten Hardmani* have been prepared by process from excellent photographs by H. Barnes, jun. The other ten plates are drawn by Frank R. Leggatt, and are very good so far as the specimens (many of which are very fragmentary) permit.

We are greatly indebted to Mr. Robert Etheridge in this, as in his many earlier memoirs, in which he has so largely contributed to our knowledge of the palæontology of the older rocks on the Australian Continent.

II.—Geological Survey of Scotland.

The Geology of Islay. By S. B. Wilkinson[1]; with notes by J. J. H. Teall, F.R.S., and B. N. Peach, F.R.S. Memoirs of the Geological Survey. pp. vii, 82, with 6 figures and 8 plates. 1907. Price 2*s.* 6*d.*

THE island of Islay is of the first importance in the interpretation of the geology of a large part of the Highlands of Scotland. The Lewisian and Torridonian rocks of the west coast there come into juxtaposition with the Central Highland schists. The one series extends northwards to Cape Wrath, the other stretches through Argyllshire and Perthshire to the shores of the Moray Firth. In Islay they meet, as they do in no other part of Scotland. The geology is complicated by the presence of another group of rocks which may be Cambrian. Only the Moine Schists and the grits and slates of the southern border of the Highlands (with the Loch Tay limestone) are wanting to make Islay a complete epitome of Highland geology. For these reasons we turn to this memoir with much curiosity to know the results of the most recent work in this quarter.

The structure of the island is sufficiently simple in its broad outlines. On the west there are Lewisian and Torridonian rocks, both in their typical development. The Lewisian is penetrated by many sills and dykes of epidiorite. Both sets of rocks have been locally much crushed. On the east side of Islay we have the Central Highland schists (Blair Atholl or Islay limestone, black schist, and Ardrishaig phyllites) with a group of quartzites, dolomitic shales, etc. Between those two formations there is a conglomerate, the Portaskaig conglomerate. There seems to be no doubt that the quartzite group rests upon the limestone, and that there is a slight unconformability at the junction.

Nearly through the middle of the island there runs a great north and south thrust-plane, a continuation of the series of post-Cambrian thrusts of the north-west of Scotland. To the west of it lie the Lewisian and Torridonian, to the east the Central Highland schists and quartzite. The break is absolute. The two sides of the island are entirely unlike; only the epidiorite sills are found on both sides of the thrust (if we except the Tertiary dykes and later rocks). This is a great disappointment, for it means that Islay gives no direct clue to the time-relationships of the two sets of rocks which form its opposite sides. The interest centres, accordingly, in the north-east corner of the island, where the quartzite and Central Highland schists are folded together in intricate fashion.

The quartzite group of Islay, resting unconformably on the Central Highland schists, possesses many features which give it a strong resemblance to the Cambrian rocks of Sutherland. The lithological characters and apparent succession are the same; there are sandy dolomitic shales, with worm-castings, which are described as 'fucoid beds.' In the quartzite there are several kinds of worm-burrows which are strictly comparable with those found in the Assynt

[1] [We have every reason to believe that S. B. Wilkinson, above-named, is the same as B. S. N. Wilkinson, part author of memoir on the Geology of West Gower, noticed in the August Number of the Geol. Mag. Bibliographers may, however, be puzzled.—Edit.]

quartzite. Dr. Peach describes these as "exactly similar to those which characterise three of the zones into which the upper part of the Cambrian quartzite or 'pipe rock' of the North-West Highlands has been divided by the Geological Survey" (p. 44), and reading between the lines one can see how strongly he has been impressed with the evidence. Yet these rocks are nowhere stated, in map or memoir, to be Cambrian. Most unfortunately the final proof is lacking; careful search in the dark shales of the north of Islay has failed to yield any trace of the fauna of the *Olenellus* zone where its presence might confidently have been predicted.

The reasons for the great caution with which this subject has been handled are not explicitly stated in the memoir; we are left to gather them for ourselves. If the Islay quartzite be Cambrian this carries with it important results in Highland geology, as this quartzite extends into Jura and Scalba. By means of its boulder beds it can be identified with certain quartzites in Argyllshire and with the quartzite of Banffshire. The Cambrian colours would sweep into the mainland, reaching right across Scotland. The Central Highland schists would be a sub-Cambrian formation, not always certainly separated by an unconformability from the quartzite, and much of the folding and metamorphism of these rocks must be of post-Cambrian date. This gives us pause, and we can sympathise with the authors in hesitating to found generalizations of this order on evidence which is not in itself incontrovertible.

The memoir, for the area covered, is a brief one, not cumbered with topographical or petrographical details. It is illustrated with some fine photographic views and contains a bibliography of Islay geology. The editorial work has been well done, and the contributions by the different authors are skilfully joined, so that the chapters read smoothly throughout. The book gives us the impression of minutely careful work, carried out in a spirit of judicial impartiality and described with clearness and reserve. The unsettled problems of the geology of Islay lose none of their fascination from the treatment they receive in the memoir, and Islay remains one of the most beautiful and perplexing of the islands of Scotland.

CORRESPONDENCE.

SOURCE OF AUSTRALIAN ARTESIAN WATERS.

Sir,—In your September issue your reviewer mentions incidentally Professor Gregory's views on the source of Australian artesian waters. These views are perhaps best illustrated by the following quotations. "Most of the water is an old accumulation, some of which may have been derived by percolation from meteoric sources; much of it is probably of plutonic origin; and some of it may be old sea-water from the Cretaceous beds" ("Australasia," pp. 104, 105). "It is therefore possible to explain the occurrence of the deep-water supply in Australia independently of the present rainfall" ("The Dead Heart of Australia," p. 288). I have elsewhere in your columns (November, 1906) shown that the 'plutonic' origin or 'juvenile' state of geyser waters is far from being established. I now desire to

show as briefly as possible, from "The Dead Heart of Australia" itself, that much of the data on which Professor Gregory relies, and to which he often gives the value of established facts, is pure assumption. Professor Gregory assumes:—

(*a*) That subterranean waters may be derived entirely from cooling magmas, and that the steam issuing from volcanoes is so derived. (p. 286.)

(*b*) That the majority of important ore-bodies are due to 'plutonic' or magmatic waters, and that, as there are numerous ore-bodies near the Australian artesian strata, there is consequently an abundance of 'plutonic' water beneath. (p. 287.)

(*c*) That, notwithstanding the general synclinal arrangement of the artesian strata (so far as they are known), and the unlimited motive force presumably inherent in 'plutonic' waters, these 'plutonic' waters would be retained within the strata. Mound springs and hot mud springs certainly do occur, but their yield is microscopic compared with the hundreds of millions of gallons the artesian beds are capable of furnishing daily. Further, it is assumed that there is a complete analogy between the retention within the strata of the Australian hot artesian waters and of the oil and gas of the Caspian and Pennsylvanian districts, despite the synclinal arrangement of strata in the former case and the anticlinal arrangement in the latter. (p. 287.)

(*d*) That flowing wells may be due to the pressure of an overlying sheet of impermeable rock, citing in illustration a tin bottle filled with water, the mouth closed with the exception of a pinhole, and pressure *then* applied to the side (p. 289). The analogy is inexact, since the pressure existed before the water-beds were filled with the water they now hold.

(*e*) That the calculations for rainfall, surface evaporation, and percolation in the neighbourhood of Lake Eyre and in Central Australia are applicable to a water-bed there 2000–3000 feet below the surface, or to an intake area far away in Eastern Australia. (p. 325.)

(*f*) That a complete analogy exists between the cold waters of the quicksands of the Kilsby tunnel near Rugby and Australian artesian waters (p. 300), yet the latter have gained heat and hence power.

(*g*) That the disposition, dip, and character of the deep water-bearing beds are so well known as to preclude the possibility of irregularities in bore pressure being due to these factors (pp. 305 et seq.). But, for example, there may exist at no great depth beneath the surface a north-west prolongation of the Palæozoic rocks that outcrop west of Thargomindah. Some little support is given to the supposition by the shallowness of the Tonko bore, only 250 feet deep. An anticlinal arrangement of water-bearing strata on such a granite ridge would, from the flood-waters of the Barcoo and the Diamantina, feed both a Lake Eyre artesian basin and the great central Queensland basin. The geology of the region is, however, unknown.

(*h*) That the salinity of the unknown beds traversed by the underground waters is practically uniform. (pp. 312–314.)

(*i*) That there are known and well-established criteria of 'plutonic' waters; that 'mineral waters' are of necessity 'plutonic' waters; and that the presence of alkaline carbonates in waters is a sufficient guarantee of their 'plutonic origin.' (pp. 315, 316, 339.)

(*k*) That waters heated to no more than 96° to 139° F. are, by reason of their temperature, 'plutonic' waters. (p. 317.)

(*l*) The impossibility of the derivation of the oil or gas of, say, the Alice Downs well from intercalated sedimentary beds. (p. 318.)

(*m*) That tidal wells are entirely analogous to geysers. (p. 328.)

(*n*) The impossibility of water percolating from overlying sedimentaries into fissures in granite (Oxton Downs). (p. 339.)

(*o*) That "if the water be of meteoric origin, it must continually be enlarging the underground fissures" (p. 340), and this despite the weight of 2000–4000 feet of strata already quoted by the author (p. 289) as a sufficient cause of flowing wells.

Professor Gregory throughout assumes—

(*p*) The impossibility of meteoric waters descending to sufficient depths to gain the temperature observed; and

(*q*) The impossibility of the observed gases and contained solids being derived from chemical interaction within the sedimentary strata.

Finally, Professor Gregory loses sight of the great facts that thousands of square miles of the granite through which his 'plutonic' water is supposed to have come is exposed to our investigation, and that the granite is presumably now in exactly the same condition as during the Tertiary period, when his waters were accumulating. While the fissures in the upper 500 feet of this granite contain water, as in the Queensland and Westralian mining fields and in the numerous bores near Camooweal, yet whenever great depths are reached, as the 2,600 feet at Charters Towers, with lesser depths on other Queensland fields, and the 2,000 feet of the Coolgardie bore and the Kalgoorlie mines, the granites and older rocks are dry. But Professor Gregory's theory demands, in view of the daily yield of 450,000,000 gallons, a widespread present distribution in the granite of fissures filled with hot water and extending to great depths.

With the foregoing protest against the elevation of pure assumption to the commanding position of ascertained fact I am content to leave the full discussion of the subject to the capable pens of my former colleagues in Australia, who have had a wider personal knowledge of the artesian area than I possess.

MALCOLM MACLAREN.

NOMENCLATURE OF AUSTRALIAN SILURIAN OPHIURIDS.

SIR,—A few points in Dr. Bather's article "Australian Palæontologists on Silurian Ophiurids" call for further comment. Taking Dr. Bather's remarks *seriatim*, it would appear that I had flagrantly transgressed certain established rules of nomenclature, since he says that I seem "for the moment to have forgotten the perfectly definite and, one had thought, universally accepted rule of nomenclature, according to which the genus must follow its genotype. In other words, *Sturtzura* must become a simple synonym of *Protaster*." In changing the genotype, reference was made to the Stricklandian Code of Rules of Zoological Nomenclature (which forms the basis of the several later codes), where, in paragraph 5, it says: "When the evidence as to the original type is not perfectly clear and indisputable, then the first person who subdivides the genus may affix the original

name to any portion of it at his discretion," etc. In the present instance, however, Professor Gregory did select the genotype, but had the conception that the arm-structure was similar to the accompanying form, *leptosoma*. Since, therefore, the genotype was selected in error, it is necessary to follow an unwritten, but nevertheless, patent rule, reforming the genus thus broken up, and instituting the only remaining form—regarded as congeneric, be it remembered, by Gregory—as the valid claimant. The Stricklandian rule quoted above should afford sufficient authority and reason for such procedure, otherwise rules of nomenclature, made with the best intent, may easily prove a stumbling-block to scientific progress, and a cause of confusion, instead of a simplifying of scientific terminology.

In the interpretation of the lateral ossicles in the two species of *Sturtzura*, it may be more convenient to regard the curved, fusiform ossicles as an intermediate series—derived from a boot-shaped ambulacral, but now perfectly distinct—and to still refer to the spine-bearing plate, as Dr. Bather suggests, as the adambulacrals. In fact, there seems a transitional tendency shown in these forms, from the typical Protasterid towards a Lapworthurid, especially as there is some indication of the ventral arm-ossicles tending to become parallel on the distal and proximal margins.

Dr. Bather's suggestion that *Sturtzura* can lapse and be resuscitated under a fresh diagnosis with *S. brisingoides* and another species is surely untenable? As the original genotype is now shown to be a form of *Protaster*, this action would be condemned by the rule adopted by many zoologists of "once a synonym always a synonym" as applying to generic terms.

The last paragraph of Dr. Bather's excellent and suggestive review needs no comment, for no one responsible for museum arrangement would seriously entertain the idea of translating into free English every scientific term on the exhibited labels.

F. Chapman.

National Museum, Melbourne.
August 21st, 1907.

A CORRECTION.

Sir,—In my paper "Notes on the Invertebrate Fauna of the Uitenhage Series in Cape Colony," published in the present volume of the Geological Magazine, July number, pp. 289–295, an inaccurate statement was inadvertently allowed to pass into print. With reference to an assemblage of fossils mentioned on p. 290, the following sentence occurs, commencing on line 21 from the top of the page: "All these, so far as we know, are confined elsewhere to the Cretaceous rocks . . . ." This statement should not, of course, refer to the genus *Solecurtus*, and the sentence should read as follows: "All these, with the exception of *Solecurtus*, are, so far as we know, confined elsewhere to the Cretaceous rocks . . . ."
I hope you will be able to give publicity to the correction of this oversight.

F. L. Kitchin.